THE UNIVERSITY OF HULL

Food Safety Policy and Management: A Case Study of Implementing the HACCP System in the Fish Industry in the Sultanate of Oman

Being a Thesis submitted for the Degree of Doctor of Philosophy in the University of Hull

By

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2002

Acknowledgements

I would like to thank the following:

Dr. Andrew Palfreman for his supervision, encouragement, thorough proofreading, honest and valuable comments.

Dr. Ahmed K. Al-Rawahy (former Minister of Agriculture and Fisheries); without his help and support, it would not have been possible.

Dr. Hamed Al-Oufi for listening and sharing in the pain of research

Friends and colleagues in Hull and the Ministry of Agriculture and Fisheries, for offering me hospitality and friendship.

Kathryn Spry for correcting my English.

Above all to my family to whom I owe everything that I am and I own. Their magical love, support, encouragement and caring have been appreciated during all these years. Thanks to them, and for them, I have been able to carry out this work!

Abstract

Oman is one of the most important countries engaged in fishing in the Middle East. Fishing and agriculture have been traditional Omani occupations and sources of food and employment for the people in Oman. Over the last 40 years, many major food-importing countries have established strict hygiene regulations and legislation, including definitive standards for fishery products. Many countries exporting fishery products, particularly developing ones, did not have the mechanisms in place to meet such requirements. This led to rejection of consignments and economic losses, a fate suffered by Oman in 1997.

Since 1997 Oman, has adopted a preventive approach to food safety, inspired by Council Directive 91/493/EEC and Commission Decision 94/356/EC. The acronym HACCP (standing for Hazard Analysis Critical Control Point) denotes the management philosophy and family of techniques employed to implement the preventive approach.

In the light of these factors, it was considered important in this study to examine, through case studies, the extent to which HACCP principles and associated practices were being applied within the fish industry. Thus the difficulties of their application in practice would be assessed, and their reception in the fish processing industry reviewed. To meet this gap in knowledge, a survey was designed and carried out in all Omani regions. Such a study would determine the problems, as seen by the industry, that obstruct the proper implementation of HACCP.

The aim of this study is to explore the process of HACCP implementation in the Omani food sector, using the seafood processing sector as a case study. To carry out this study,

a triangulation method was employed to collect and validate both qualitative and quantitative data. A questionnaire was employed as the main method of data collection supplemented by semi-structured interviews of key-informants together with the application of a checklist against existing practices in the plants.

The analysis of the food safety policy and management in Oman, in relation to the food industry as a whole, reveals that most problems experienced are those related to: a poorly developed institutional and legal framework; weak technical regulations; ill-defined inspection and approval procedures; lack of skilled staff for inspection and laboratory testing; many sub-standard processing factories; and the absence of adequate infrastructure for fish marketing.

At the level of individual businesses, fish processing strategies for HACCP system implementation were investigated. The findings of this study are that most Omani fish processors are focused primarily on the development of their HACCP plans. Although developing of the HACCP plan is a fundamental part of the HACCP process, it is not widely understood among managers that this is just the beginning. The implementation and sustaining of a HACCP system can be a difficult and time-consuming mission. The study attributes this weakness to three main elements: poor training of personnel; shortcomings in prerequisite programmes; and a lack of commitment to maintenance of HACCP.

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Abbreviations

Aw	Water Activity
CAC	Codex Alimentarius Commission
CCP	Critical Control Point
DGF	Directorate General of Fisheries
DGHC	Directorate General of Health Control
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration (USA)
FSC	Food Safety Committee
GATT	General Agreement on Tariffs and Trade
GMP	Good·Manufacturing Practice
GDP	Gross Domestic Product
HACCP	Hazard Analysis Critical Control Point
ICMSF	International Commission on Microbiological Specifications for Foods
ISO	International standard Organisation
MAF	Ministry of Agriculture and Fisheries (Oman)
NACMCF	National Advisory Committee on Microbiological Criteria for Foods
Nm	Nautical miles
OR	Omani Rile
WHO	Word Health Organisation
WTO	Word Trade Organisation

Chapter One

Introduction and Study Background

1.1. Introduction

Food is one of the most important commodities of life. It accounts for a major share of expenditure in most households all over the world and contributes significantly in both national and international trade. Food affects our life physically and financially. In earlier times, compared to today, most food was eaten close to where it was harvested and consumed soon afterwards. Food now is often transported large distances to the consumer, usually under some form of refrigerated preservation. Thus, food is traded as a commodity, and quality standards are important for such trade. All through history there has been a perception that government needs to protect citizens against unsafe food and from fraud. Therefore, the task of keeping our food supply safe is a very important issue that concerns people at both national and international levels.

Since the beginning of the 20th Century, vast changes have occurred in the way food is produced and distributed. As the world population increased with subsequent demand on food supply, large-scale agricultural production of food crops and animal products increased, with the use of fertilizers, pesticides, medicated animal feed and other biologically active substances that may become residues in food and cause a potential health risk. Food processing, preservation and distribution have also become more complex. Processing methods, such as aseptic packing, irradiation treatment, use of additives, convenience packs and centralized processing and other types of treatment also add up to increased hazards (Lindenmayer, 1999). Thus, all countries need adequate food control programmes to ensure that national food supplies are safe, of good quality and available in adequate amounts at affordable prices, to ensure an acceptable nutritional and health status for all population groups.

Food control may be defined as conditions and measures to ensure the quality, safety and honest presentation of the food at all stages, from primary production, through processing and storage, to marketing and consumption (Miyagishima et al., 1995). In other words, the concept of food control implies a national effort involving an integrated approach between government and all segments and sectors of the food industry. Blanchfield (1980) argues that food control is concerned with establishing whether what has been done and produced conforms or conflicts with legal requirements and with dealing appropriately with infringements and transgressions.

Food safety control as we know it today has existed for at least a century, when many developed countries initiated the current pattern of food safety control (HMSO, 1976; FAO/WHO, 1976a). International concern for food safety also started early in the previous century and became organised by about the middle of the 1900s (Zimmerman, 1969).

Whilst most developed countries have workable food safety control systems, many developing countries are still struggling with the problems of unsafe food, which might result in not only health hazards from foodborne illness but also losses of foreign exchange.

Thus developing countries trying to establish food safety control programmes or strengthen existing ones can benefit from the experiences of developed countries and from work that has been done by international organisations (for example FAO/WHO). However, to design an effective food safety system, adequate consideration must be given to the social, economic, technological and environmental conditions in a particular country.

Studies of food safety programmes in developing countries, such as Oman, are scarce. Analysis of how food safety policy currently works and is likely to develop in Oman can illustrate some of the general characteristics of this policy in other developing countries. Public programmes for food safety tend to be quite varied (WHO, 1996), as safe food may be assured by different combinations of actions by government, industry, and consumers, so countries may well have something to learn from the experience of others.

The key objective of food safety programmes, however, is to improve the health of consumers by reducing foodborne diseases with the development of a country's economy and by increasing foreign exchange earnings through increased food trade as a secondary aim.

Despite the progress in medicine, food science, and the technology of food production, illness caused by foodborne[1] disease/pathogens continues to present a significant harm in terms of both health and economics. A review of available literature shows that not only have there been increases in reported cases of known foodborne diseases, but there have also been increases in the number of new pathogens transmitted through food. In 1990 an annual average of 120 cases of foodborne illness per 100,000 population were reported from 11 European countries (Sockett, 1991). Estimates based on study indicate that in some European countries there are at least 30,000 cases of acute gastro-enteritis per 100,000 populations annually (Notermans and Van der Giessen, 1993; Hoogland et al., 1998). However, only a small proportion of cases of foodborne illness are brought to the attention of food inspection, control, and health agencies.

Estimates have been made of the economic consequences of foodborne illness, in terms of the cost incurred by individuals who become ill, their employers, families, health care agencies, and the food businesses involved. Sockett (1991) reports that in England and Wales, some 23,000 cases of salmonellosis resulted in overall costs of £40-50 million. The validity of statistics relating to foodborne diseases could be questionable; it may be argued that recent increases in cases are consequences of increases in reporting due to public awareness and concern about food safety. Nevertheless, it is accepted that, for most diseases, cases officially reported often represent a small fraction of the actual problem in the population, as reported by Donaldson and Donaldson (1993). Trickett (1992) also estimates that unreported cases of foodborne diseases in the UK could be ten times as high as the available official figure. The Food and Drug Administration in

[1] A foodborne disease is defined as a disease of an infectious or toxic nature caused by, or thought to be caused by consumption of contaminated food or water (WHO, 1989a).

the USA believes that only about a third of all cases of foodborne diseases are actually reported (FDA, 1994a). There is a considerable potential for underreporting of foodborne diseases in both developed and developing countries. The extent of the problem in developing countries can hardly be quantified with reasonable accuracy, due to lack of sufficient data (WHO, 1984). Mortajemi et al. (1991) acknowledge that a plethora of conditions in these countries place them at far greater risk of ill-health and economic losses from foodborne diseases.

Therefore, in developing countries, policy makers need to change their attitude toward food safety services as a resource consuming, non-profitable project. Policy makers are encouraged to take food safety seriously, considering its benefits and its health and economic implications.

Economic impact

Equally important is the effect of foodborne diseases on economics and finance at both national and international levels.

On the firm level, food safety is one of the most critical issues to the manufacturers of food products. No manufacturer wants to process or sell products which may be cause injury, illness, or death of a consumer. In addition, failure to assure the production and distribution of a safe food product can have devastating consequences for a food manufacturer. An unsafe product which has harmed someone can result in legal actions by consumers and/or unwanted publicity that directly affect the company's products. Producing and selling an unsafe product may also result in regulatory actions and in the closure of the business.

International marketing of food is big business and for many exporting countries, especially developing countries, food exports are a major source of foreign exchange. To compete effectively with other food exporting countries and maximize foreign exchange earnings, a country like Oman, for example, must ensure that its food products are of sufficient quality to be acceptable and competitive[2]. The international food trade is extremely competitive and the requirements of the most profitable markets are the most sophisticated and demanding (Caswell and Mojduszka, 1996). Exporting is sometimes made more difficult by untruthful exporters seeking larger profits by adopting unsafe practices that may threaten the health of consumers or tarnish their country's commercial image, or both.

All responsible food producing countries need to ensure the acceptability of the quality of the food they export by adopting measures to prevent dishonest practices in the export food trade. An important issue for Oman is to determine its priorities in establishing a policy for utilizing its national, and often scarce, resources. The fewer the resources, the harder the task and the more difficult it is to decide how to get the maximum return from each unit of resource invested.

This thesis focuses on Omani processed fish. Fish is an important commodity of trade for developing countries. Almost all developing countries export some fishery products and for most of them the revenue from these exports is a major source of foreign currency. Seventy percent of the world's catch of fish and fishery products is consumed as food (Karnicki, 1997). Fish and shellfish products represent 15.6 percent of animal protein supply and 5.6 percent of total protein supply on worldwide basis (Lem and Shehadeh, 1997).

[2] Competitiveness means the ability of a firm to maintain and increase market share over a sustained period of time (Holleran et al., 1999). Yoram (1992) discusses indicators of competitiveness.

Developing countries are responsible for more than 50 percent of fish and fishery products involved in international trade (Lima dos Santos, 1997). Developed countries, like the European Union, Japan and the United States account for about 80 percent of world fish and fishery product imports (Karnicki, 1997). They dominate the market in terms of both prices and quality requirements. In 2000, Oman exported 35,000 metric tonnes (29% of the total fish landed) of seafood products, valued at £29 million (Ministry of Agriculture and Fisheries, 2001).

However, in the international fish and fishery products businesses, one of the most serious difficulties faced by exporters from developing countries is the variation between standards and regimes being imposed by importing countries to ensure products meet their domestic requirements[3]. The differences between the legislation, organization and function of inspection services are among the most important practical difficulties faced by developing countries in complying with the requirements imposed by importing countries (see Chapter Three). The certification requirements of different countries cause inconvenience to both the exporter and the responsible government regulatory agency. There are a number of different forms and languages, which often result in confusion. The other serious difficulties are the quality of raw materials, mainly due to poor practices of fish handling, preservation and storage on board of fishing vessels, as well as poor handling, unloading and transportation practices ashore. Pre-processing operations, mostly carried out outside the plants, under rather poor technical, hygienic and sanitary conditions, are often the main cause of contamination and decomposition.

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[3] Examples of such requirements are the EU Council Directives of 22 July 1991 (91/493/EEC) laying down the health conditions for the production and placing on the market of fishery products and the Commission Decision 94/356/EC laying down detailed rules for the application of Directive 91/493/EEC as regards "own health checks" on fishery products and Council Directive 93/43/EEC on the hygiene of foodstuffs.

Seafood safety cannot readily be purchased as a commodity in the marketplace and governments feel obliged to intervene to regulate the safety and quality of seafood. Since 1997 Oman, like other developing countries, has experienced some difficulties with exports to the EU because of the lack of appropriate quality control measures. The main objectives of the European Union measures are to assure the safety of these products and to avoid systematic detention, heavy sampling and laboratory checks at the point of entry. A shift to the systematic preventive approach is an important technical characteristic of the new inspection and quality control procedures required under the Council Directive 91/493/EEC. The subsequent adoption of the HACCP system as a result of this Directive and the definition of detailed rules for its implementation in Commission Decision 94/356/EC in those countries that wish to export to the Community is a major component of the changing global policy regime. Appendix X to this thesis includes an analysis of the linkages between the empirical research methodology employed in the thesis and the constituents of these two items of European law.

In the United States, HACCP was mandated through regulation for seafood in 1994, for meat and poultry in 1996, and proposed for fresh fruit juice in 1998, with regulations for other food industries expected (Morris, 1997). Australia, New Zealand, and Canada also have mandatory or voluntary public programmes to encourage the adoption of HACCP (Peters, 1997; Dean, 1990).

As an outcome of its use in most developed countries, HACCP is increasingly practised in developing countries that export food products to industrialized markets (Merican, 1996). The growing use of HACCP as a sanitary standard in international trade led

Codex Alimentarius to adopt guidelines for HACCP in 1993, and to incorporate HACCP into food hygiene codes starting in 1995 (Whitehead and Orriss, 1995).

Many countries are responding positively to implementing HACCP in their fish exporting subsector (see Chapter Three and Appendix IX). A result of the adoption of the HACCP concept is to direct energy and resources toward areas where they are most effectively applied. It shifts the emphasis of control from the testing of end-products to preventive control of all critical operations of the process. This makes HACCP an ideal tool where resources are scarce. It may appear a complex and an impossible target to upgrade an underdeveloped industry. However, by using the HACCP concept it is possible to identify where the necessary changes and improvements should be introduced.

HACCP implementation and maintenance is not easy. It requires management commitment, an understanding of the system and its principles, and a commitment of resources to design and monitor the system. To achieve these goals, industry and government should be convinced of the necessity and reasons to apply HACCP. How far have industry and governments really gone towards introduction of the HACCP concept in their daily operations in Oman? This is one of the questions that this research aims to explore.

1.2. The need for the study

Fisheries have traditionally played a significant role in the social and economic development of the Sultanate of Oman (see Chapter Four). They have been an important source of nutritious food and the primary source of livelihood for thousands of fishermen and their dependents in virtually all communities along Oman's 1700 kilometres coastline. Although the economic role of fisheries has been overshadowed by the petroleum industry in the last thirty years, the fisheries sector has made a significant contribution to the national economy. It has generated economic activity, earned foreign exchange, and assisted the Government in realizing its policy objectives of economic diversification and rural development.

After the EU ban on Oman exports in 1997, the concern has increased. The total value of Oman's fish exports to the EU averaged £8.5 million, between 1995-1997. Unless other markets were identified, a serious loss of revenue to the country would have resulted from the European ban on Omani exports. The evidence of this thesis is that fish processing companies are aware of HACCP and claim to have implemented it, but their understanding and execution are weak; and they are still looking for government support. Three years since the introduction of HACCP in the seafood industry, before this research, little was known about fish processors' knowledge of, attitudes towards, and opinions on the HACCP system. To meet this gap in knowledge, a survey was designed and carried out in all Omani regions. Such a study would determine the problems, as seen by the industry, that obstruct the proper implementation of HACCP.

1.3. Aims and objectives

1.3.1. Aims

The aim of this study is to explore the process of HACCP implementation in the Omani food sector, using the seafood processing sector as a case study. The seafood processing sector has been chosen as the case study for two main reasons. Firstly, it is one of the few sectors within the Omani food processing industry that is subject to a legal requirement (EU Council Directive of 91/493/EEC) to implement a food safety control system[4]. Secondly, the commodity-type nature of many seafood products makes it easier to discern the process by which HACCP is implemented. Whilst the results of the survey are clearly specific to the seafood processing sector, it is anticipated that they will provide information which is more widely applicable to the food processing sector as a whole in Oman.

1.3.2. Objectives

A survey of the food industry in Omani fish industry regarding the implementation of the HACCP system is presented. The objectives of the survey are:

- To establish the level of implementation of HACCP systems, to obtain information of industry's hazard awareness and to establish the barriers to HACCP implementation.
- To identify factors that affect HACCP implementation.
- To estimate the implementation costs of HACCP.

Since there is no published indication that previous studies of this kind have been undertaken on HACCP implementation in Oman and as HACCP has become mandatory for those who want to export their products to the US and EU countries, in this study a step-by-step assessment was conducted of HACCP programme implementation in Omani fish processing plants. Fish processors instituting a new HACCP programme should benefit from a review of this process, and those who already have a HACCP programme should benefit because the study checks that the programme is focused on

[4] Although Council Directive 91/493/EEC is an important influence on the content of this study, illustrated in Appendix X as well as elsewhere in the thesis, the thesis is concerned specifically with

safety and comprehensively covers all areas. In addition, the findings provide a benchmark against which progress in this area can be assessed in future.

This thesis is divided into nine chapters. The first chapter (this chapter) introduces the study background and problem, its aim and objectives. The second chapter reviews the literature on microbiology and food safety, the HACCP system, the practical implementation of HACCP, and food safety strategies. The third chapter assess the impact of Council Directive 91/493/EEC on seafood export to the EU from developing countries. The fourth chapter evaluates the fish quality control system in Oman. The fifth describes existing food safety control in food sectors in Oman and its implications, and suggests mechanisms to improve it. The sixth chapter describes the research design and procedures used to collect data from fish processing companies in Oman. The seventh chapter presents the results. The eighth chapter discuss those results. The ninth provides a conclusion and offers recommendations based on the current investigation. In addition to those chapters, a list of references and appendices are also provided.

This study supplies an insight into the actual status of the application of HACCP-based quality assurance systems throughout seafood processing. The presentation covers the industry side as well as the government sector, emphasizing the main benefits, difficulties, and problems faced by the players in applying HACCP and giving suggestions for future work. The situation is dynamic, volatile, and changes almost daily and reflects the best of the researcher's knowledge at the time the survey results were analysed.

HACCP planning and implementation.

Chapter Two

Literature Review

2.1. Introduction

A review of the literature in the areas of recent research on food safety, food control legislation, guidance and codes of practice, and HACCP techniques were undertaken. This review was prepared partly to supply a solid foundation for the remainder of the study and partly so that the main beneficiary of the current study, the country of Oman, is comprehensively acquainted with the issues surrounding the use of the HACCP system. The review includes texts, journal articles, legislative and policy documents, and recent conference papers.

The literature review comprises five sections. The first section examines the epidemiological rationale for the application of the HACCP system to food safety control, and discusses some common foodborne hazards of importance in the food industry. The second section presents a historical review of the HACCP system. The third section is a description of the philosophy and tools that are necessary to ensure the working of a HACCP system on the factory floor. The fourth section presents the role of the main players in adopting and promoting HACCP and discusses barriers in implementing HACCP. The fifth section discusses the implications for Oman from the documentary details provided in the first four sections.

2.2. Microbiology and food safety

Plant and animal agricultural products have a wide range of microbes on or in them at harvest or slaughter. The numbers and types of microbes that comprise this primary contamination vary from one commodity to another, with geographic region, and with production and slaughtering or harvesting methods. Some can grow on the food causing spoilage; others constitute a hazard to man through illness caused either by infection or by intoxication after they have grown in the food and produced a toxin. ICMSF (1988) classifies the agent of disease as biological (e.g. microorganisms), chemical (e.g. pesticide residues, toxic metals and natural toxins) or physical (e.g., hair, dirt).

Microbiological considerations are a challenge to the quality and safety of food because potentially harmful microorganisms have the ability to grow rapidly from very low numbers either in the food or in the consumer (Tent, 1999). Microorganisms were first observed and described by Leeuwenhoek in 1683, but it was not until 1837 that Pasteur first associated bacteria with food spoilage. The demonstration that diseases are transmitted via foods was successfully achieved in the 19^{th} century (cited in ICMSF, 1988).

2.2.1. Foodborne hazards

A foodborne disease is defined as a disease of an infectious or toxic nature caused by, or thought to be caused by, consumption of contaminated food or water (WHO, 1989a). A hazard is defined by FAO as a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect (FAO, 1998) and by the European Commission as "a potential to cause harm to health and is anything covered by the hygiene objectives of Directive 91/493/EEC" (Commission Decision 94/356/EC).

A number of biological, chemical and physical hazards are associated with seafood. Some of these hazards are specific to fish and/or shellfish and are related to the environment where the animals are captured. Others are more general in nature since fish and shellfish, like any other food, may become contaminated during processing, and growth of pathogens may take place in the production process. Huss (2000) points out that the gross chemical composition and spoilage associations of meat and fish are very similar. However, fish are much more perishable and, constitute better substrates for growth of pathogenic bacteria because of pH difference (pH 5.5 and 6.8 for meat and fish, respectively) and lower glucose levels. Though the internal muscle tissue of fresh fish is sterile, bacteria are present on the outer slime layer of the skin, on the gill surfaces, and in the intestines. The most easily spoiled area is the gill region.

A. Biological hazards

There are two means of bacteria poisoning. They are bacterial infections and bacterial intoxications.

Tzouros and Arvanitoyannis (2000) state that the population and composition of microflora[1] on finfish are influenced by the temperature of seawater, the area where they were caught, the season of catching, the level of sanitary precautions during harvesting, handling and processing, and others factors. Huss (2000) comments that, live fish, crustaceans and raw products may be contaminated by a number of pathogenic bacteria normally found in the aquatic environment, such as *Clostridium botulinum, Vibrio parahaemolyticus,* various *Vibrio* sp., *Listeria monocytogenes,* and *Aeromonas* spp. However, strictly speaking, it is the growth of these organisms that can be regarded as a hazard, as pathogenicity is normally only related to preformed toxin in the food *(Clostridium botulinum)* or when the minimal infection dose is known to be high (*Vibrios)*. The severity of diseases related to these organisms may be high (botulism, cholera) or low *(Aeromonas* infections), but the likelihood of provoking diseases (risk) is low.

Most fish and crustaceans are cooked before eating although a few countries (Japan) have a tradition of eating raw fish. The epidemiological records show that fish cooked immediately before consumption have caused a number of food poisoning outbreaks, but nearly all are related to the presence of heat stable toxins (e.g. biotoxins and histamine). Knowledge of the preservative principles involved *(aw,* pH, smoke, preservatives, etc.), packaging and preparation before eating (cooked or uncooked products) might have assisted in the evaluation of these hazards.

[1] The predominant microflora in fresh finfish include *Acinetobacter, Aerobacter, Aeromonas, Alcaligenes, Alteromonas, Bacillus, Clostridium, Corynebacterium, Flavobacterium, Micrococcus, Moraxella, Proteus, Pseudomonas,* and *Vibrio* (Hsing-Chen Chen, 1995). *Vibrionaceae, Salmonella, Campylobacter jejuni, Clostridium botulinum, Shigella, Staphylococcus aureus,* hepatitis A virus, non-A non-B enteral hepatitis virus, Norwalk and related viruses, and helminths *(Anisakis simplex, Diphyllobothrium)*

Problems may occur when there is negligence and improper handling. The pathogenic strains of many bacteria require temperatures > 5°C for growth and they compete with the normal spoilage flora which proliferate comparatively more rapidly at low temperatures (Huss, 2000). Thus many fishery products are likely to be spoiled before the production of toxin or the development of high numbers of pathogens. When the products are cooked before consumption, this will eliminate the risk, as the bacteria and their toxins are heat sensitive.

Bacterial infections

Some common bacterial infections are *salmonellosis*, paratyphoid fever, typhoid fever, *Vibrio parahaemolyticus* infection and *shigellosis.*

Salmonella spp. is facultative anaerobes often associated with under-cooked foods, faecal contamination, poor personal hygiene and raw-to-cooked cross-contamination. Infections exhibit themselves as gastrointestinal diseases between 6 and 48 hours after ingestion. Beveridge (1988) and Fenlon (1983) state that the symptoms of the disease may persist for 2 to 5 days, and include vomiting, diarrhoea, nausea, abdominal pain and fever. Apparently healthy individuals, on recovery, may remain carriers of the organisms for months or even years. *Salmonellae* are not very tolerant to cooking or freezing, but survive chilling and will grow at temperatures as low as 5°C.They are resistant to drying and tolerate up to 8% salt (Table 2.1). The organisms are difficult to detect. They are normally only checked for when a high incidence of "indicator" organisms (e.g. coliforms and faecal *coli*) has been found in a raw material or product.

Pathogenic bacteria from the animal/human reservoir *(Salmonella, E. coli, Shigella, S. aureus)* may contaminate the live animal depending on the fishing area and further contamination may take place during landing and processing. Huss (2000) notes that the diseases which these organisms can provoke are serious, but if numbers on the products are low (i.e. no growth has taken place) the likelihood of this to happen is very low indeed. Cooking before consumption will eliminate the risk. However, an indirect risk exists if contaminated products contaminate the working areas (industry, kitchen), resulting in the pathogens being transported to products which are not cooked before eating.

Shigella spp. is more of a problem in tropical countries than temperate ones. As with the *Salmonellae*, infection occurs through the faecal/oral route and most cases in warmer countries are caused by the drinking of contaminated water (or consumption of salads washed in such water). People infected by *shigellosis* (and *salmonellosis)* remain "carriers" for a long time after they have recovered from the dysentery-like symptoms of the disease and are capable of infecting any food they handle (Huss, 2000). This is why it is normally recommended that food handlers, particularly those working in high-risk areas, should be regularly screened (through stool-testing) for these organisms. Salads and ready-to-eat seafoods, generally infected with the organism from carrier handlers, have been the principal foods responsible for this form of food poisoning.

Vibrio parahaemolyticus poisoning has its source mainly in fresh marine fish and shellfish. Secondary contamination is found in processed food (e.g. salted food). The characteristic symptoms are diarrhoea, stomachache, nausea, vomiting and fever. It takes 8-24 hours for the onset of symptoms. This food poisoning can be prevented by keeping food at low temperatures after catch to time of consumption, by avoiding secondary contamination, heating food before consumption and washing all equipment well with potable water (Ahmed, 1992).

Bacterial intoxications

Botulism is food intoxication from a preformed toxin. Botulism is caused by *Clostridium botulinum* and the foods usually implicated are improperly processed low-acid canned foods. The illness takes 2 hours to 8 days to manifest, with the peak accruing after 12 to 24 hours (Tzouros and Arvanitoyannis, 2000). There is a high incidence of death from this intoxication. The toxin affects the central nervous system, producing double vision, difficulty in swallowing and finally death by respiratory paralysis.

The botulinum toxin is considered to be the most powerful known to affect man (Tzouros and Arvanitoyannis, 2000). Its potency stems from its ability to disrupt the chemistry at nerve synapses, blocking the transmission of nervous impulses, thereby leading to paralysis. Victims are asphyxiated due to the paralysis of the musculature involved in respiration. Thus, up to the development of the technology allowing patients to be kept alive in respirators, fatality followed.

The frequency with which *C. botulinum* occurs in raw food products is low, and even when present the level of contamination with respect to the normal spoilage flora is such that the food would appear spoiled before sufficient botulinum toxin to cause human poisoning accumulates (Tzouros and Arvanitoyannis, 2000). According to the same authors the products at risk are those which have been subjected to mild or pasteurisation processing which are to be consumed without (further) cooking. Heat or irradiation pasteurised and smoke-cured products are at greatest risk, because the process has been sufficient to destroy most of the competing spoilage flora which would normally render the product inedible before it became toxic.

Staphylococcus aureus is responsible for staphylococcal food poisoning. It is an aerobic, non-spore forming organism which most of us carry on our skins and in our respiratory passages (hence its association with unhygienic handling) and has a minimum growth temperature of 5°C, although growth is hardly perceptible below 10°C (Huss, 1997). It has a high tolerance of being frozen, desiccation (growth can occur down to *aw* 0.83) and salt (up to 1 5%) (see Table 2.1). Huss (1997) notes that the toxin produced by *S. aureus* is a very small molecule of protein which resists denaturation by heat; so it tolerates boiling for a long time. The symptoms of poisoning due to this toxin are nausea, vomiting and diarrhoea, but recovery is often within 48 hours so many cases go unrecorded.

Clostridium perfringens is incriminated in foods kept under anaerobic conditions. The resulting toxin, enterotoxin, is strongly heat resistant. It is associated in temperate countries with sewage pollution as, for example, when vegetables are fertilised with raw sewage or contaminated run-off from the land finds its way to areas where animals or fish are feeding (Tzouros and Arvanitoyannis, 2000). It is a rapidly growing, anaerobic, spore forming organism with certain strains capable of growing down to 6°C and *aw* 0.93 and in the presence of up to 7% salt (Table 2.1). As a spouting bacterium it is quite resistant to cooking.

Listeria monocytogenes is a ubiquitous organism in the environment, so ready-to-eat foods (i.e. not to be cooked or reheated) are at greatest risk (Huss, 1997). The organism is salt-tolerant (growth in concentrations up to 10% and survival in saturated brine) and it grows without oxygen at temperatures down to -0.5°C but it is destroyed by thorough cooking. According to the same author its growth is favoured by cool, damp conditions, but it will grow down to *aw* 0.94 and its colonies form surface films on equipment, which are difficult to remove. To counter the likelihood of *Listeria* occurring in products, effective cleaning and disinfections of premises and equipment is required. It is normally recommended, therefore, that making aerosols, e. g. by using high pressure steam/water hoses, should be avoided; premises should be kept well-ventilated, preferably using microfiltered air; the working environment should be kept at positive pressure to avoid entry of contaminants from outside, and product should be stored chilled at < 0°C.

B. Chemical hazards

The presence of biotoxins in fish depends on fish species, fishing area and season. The toxins are heat-stable and the risk of intoxication after consumption (raw or cooked) is high. Huss (2000) reports that, the severity of the disease depends on the type of toxin, but may in some cases be high. The seafood toxicity can be classified into chemical poisons and naturally occurring toxicity.

Chemical poisons include mercury, arsenic, cadmium, lead, zinc and antimony. Cadmium poisoning takes about 15 to 30 minutes to manifest with characteristic symptoms such as nausea, vomiting and cramps. It is often fatal. Mercury poisoning from seafood affects locomotive coordination and the nervous system. This condition, known as the Minamata disease, has been found in fishing communities, and is traced to mercury discharged into the bay from factories (Reilly et al., 1997). The mercury accumulated in the fish, which were then the source of food and livelihood of the community. Methyl mercury is a potential hazard in several fish species (Taylor et al., 1989). Price (1995) notes that some marine fish, especially those at the top of the food chain such as swordfish and shark, have built up methyl mercury from their diet and may contain levels near or above the current action level of 1 ppm. Other pollutants include lead, copper, chlorinated hydrocarbons, pesticides, mineral oils and radioactive isotopes and other chemicals associated with human activities.

The second type of seafood toxicity is due to toxins which naturally occur in the seafood. The common marine food poisonings caused by toxins are ciguatera poisoning, poisoning by tetrodotoxin[2], or puffer fish poisoning, paralytic shellfish poisoning and diarrhoetic shellfish poisoning. Placing on the market of fishery products containing biotoxins, such as ciguatera toxins or muscle paralyzing toxins, is expressly forbidden by Article 5 of Council Directive 91/493/EEC.

Ciguatera poisoning is a unique poisoning due to ingestion of coral fish (i.e. fish living near coral reefs). However, not all coral fish species cause ciguatera poisoning. Ciguatera food poisoning is caused by the parasite dinoflagellate *Gambierciscus toxicus* living in barracuda, amberjack, horseye jack, blackjack, and king mackerel, among others (Price, 1995). The fish become toxic through food chain magnification. Therefore large fish carry more toxin than small fish. More than 400 species of fish have been identified as carriers of this toxin. Unfortunately there are no signs to warn the consumer when a fish is a toxin carrier. FAO (1996) recommend that the strategies for

[2] Named from the *Tetraodontidae* family, or puffer fish, which is widely distributed through tropical and temperate waters, and is normally implicated as a source. The symptoms of such poisoning can vary from a mild tingling of the lips to severe neurological malfunction, perhaps resulting in death due to respiratory paralysis or cardiovascular collapse. The poisoning is similar to that from saxitoxin but more severe. Some Japanese enjoy consuming the flesh of this fish, which is very slightly toxic, compared to the viscera which are very toxic. In Japan, restaurant dealers selling and serving this fish must get a licence certifying that they have successfully completed a course on handling, preparing and serving puffer fish.

the design and implementation of monitoring systems for the reduction of risks posed by harmful marine algae be developed.

As ciguatoxins are odourless, tasteless, and difficult to detect chemically, there has been a significant effort to develop appropriate detection techniques. Immunological assays such as RIA, ELIS A, and S-RIA (a solid-phase immunobed assay) have been used to detecting such poisoning (Park, 1994).

The characteristic symptoms are aches in joints, and "dry-ice" sensation, where the affected person is unable to feel heat but instead feels a cold sensation even when he touches hot objects. This poses a serious problem of accidental burning. Affected persons also feel "electric shock" sensations when they touch water, as cited in Park (1994).

Accumulation of toxic marine algae (dinoflagellates) in filter feeding shellfish has been the cause of countless outbreaks of "shellfish-poisoning" named according to the symptoms they provoke (Paralytic Shellfish Poisoning (PSP), Diarrhetic Shellfish Poisoning (DSP), Neurotoxic Shellfish Poisoning (NSP) and Amnesic Shellfish Poisoning (ASP). Unfortunately all the toxins (saxitoxin, brevetoxin, domoic acid, okadaic acid) are heat stable. Thus, if sufficient numbers of toxic algae are accumulated in the live shellfish, consumption will cause disease, whether the shellfish are cooked or not.

PSP is associated with the consumption of bivalve molluscs, and is produced by certain dinoflagellate plankton when, under certain climatic and tidal conditions, they accumulate in "blooms" and toxify the bivalves and crustaceans in that environment.

This is the so-called "red tide" phenomenon recurrent in tropical or semi-tropical waters. It is not only tropical marine environments which bear the risk; some strains of freshwater blue-green algae, found in temperate lakes, also carry PSP (d' Amours, 1997). Huss (2000) states that the toxins are actually saxitoxins and gonyautoxins and have been the cause of a number of deaths through respiratory paralysis. The human lethal dose is only 0.2g for the most toxic types with the onset of symptoms occurring within 1-2 hours after consumption. If sufferers survive 12 hours after the onset of the poisoning, they generally recover. The symptoms include respiratory paralysis, trembling lips to complete loss of power in the muscles of the extremities and neck.

DSP is due to the *Dinophysis* toxin. *Dinophysis fortii* and *Dinophysis acuminata* are the two plankton mainly responsible. The main symptoms are diarrhoea and nausea. The general symptoms are similar to those caused by *Vibrio spp.* poisoning. However a few patients manifest fever when suffering from DSP. This toxin is located exclusively in the digestive glands of the shellfish. Therefore the risk of being poisoned by DSP toxin is reduced if the digestive glands are removed from the shellfish before serving.

NSP is a ciguatera-like syndrome due to a brevetoxin from the dinoflagellate *Ptychodiscus brevis* transmitted to bivalve molluscs. Horie et al. (1964) and Price (1995) discuss that the organism is responsible for the best-known "red tide" bloom in Florida where it kills vast numbers of fish. It has not, however, been known to have caused human deaths, although it frequently causes respiratory irritation in people living close to where there is a toxic bloom and wave motion causes some of it to be entrained in an aerosol.

ASP was first reported in Canada in 1987 and traced to mussels from the east coast of Prince Edward Island. The toxic agent is domoic acid, an analogue of glutamic acid, produced and supplied to bivalves by species of the diatom, *Nitshia.* Apart from nausea, confusion and memory loss (possibly irreversible) in high doses, ASP toxin can cause permanent brain damage or even death.

Scombroid poisoning

Histamine poisoning is often called scombroid[3] fish poisoning. Histamine is produced by the action of histidine decarboxylase on histidine. Various microorganisms (i.e., *Enterobacteriaceae spp., Pseudomonas, Clostridium pefringens, Vibrio spp.,* and some Gram-positive halophilic and halotolerant microorganisms) are responsible for this biochemical reaction (Tzouros and Arvanitoyannis, 2000). Bacteria such as *M. morganii, Klebsiella pneumoniae*, and *Hafnia alvei* cause histamine poisoning.

Histamine levels in ungutted mackerel, stored in ice, have been found to rise to more than 50mg kg^{-1} in 10-12 days. At higher temperatures this concentration may multiply several times.

Tzouros and Arvanitoyannis (2000) state that histamine is a useful indicator of handling and/or temperature abuse having occurred at some stage of the post-harvest operations. Histamine is quite stable on exposure to prolonged high temperatures, as in canning and its level in the product may, therefore, be used to infer whether the freshness quality of the raw material is satisfactory.

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[3]Scombroid fish, including tuna, mackerel, bonito, and butterfly kingfish, contain high levels of free histidine, which is readily decarboxylated to histamine by a great variety of bacteria (Mossel et al., 1995).

Accumulation of biogenic amines will continue in fish flesh until the endogenous and exogenous (bacterial) enzymes responsible for histidine decarboxylation are inactivated by preservation or processing. In many "extended durability" fishery products, conditions of processing are so mild (compatible with the sensory requirements of the product) that this biogenesis is not inactivated but continues through storage, distribution and retail display.

The effect from growth of histamine producing bacteria *(Morganella morganii)* will not be eliminated by any heat treatment, as the heat resistance of histamine is high. The risk of histamine poisoning, if fish (particularly fish belonging to the genus *Scombroidae)* have been kept for some time at elevated temperatures (> 5°C), is, therefore, high. Determination of histamine is possible by applying an enzymatic technique that screens food specimens and bacterial strains (Rodriguez-Jerez et al., 1994). Histamine levels in fish have been much studied because of the suspected connection between high levels of histamine and vasoactive "scombroid" poisoning.

Council Directive 91/493/EEC (Chapter 5, Annex) requires that the histamine concentration of scombroid and clupeid flesh should not exceed 100mg kg^{-1} as a mean value for 9 samples with no single one of the samples exceeding 200mg kg^{-1}, which demonstrates European concern about this type of food poisoning.

Table 2.1. Type and growth characteristics of seafood hazards.

Pathogen	Minimum			Maximum			O_2
	aw	pH	Temperature	pH	% salt	Temperature	Requirement
Bacillus Cereus	0.92	4.3	4°C	9.3	18	55 °C	aerobe
Campylobacter Jejuni	0.987	4.9	30°C	9.5	105	45°C	micro-aerophilic*
Clostridium botulinum, type A, and proteolytic B and F	0.935	4.6	10°C	9	10	48°C	Anaerobe**
Clostridium botulinum, type E, and nonproteolytic B and F	0.97	5	3.3°C	9	5	45°C	anaerobe**
Clostridium perfringens	0.93	5	10°C	9	7	52°C	anaerobe**
pathogenic strains of *Escherichia coli*	0.95	4	7°C	9	6.5	49.4°C	Facultative anaerobe***
Listeria monocytogenes	0.92	4.4	-0.4°C	9.4	10	45°C	Facultative anaerobe***
Salmonella spp.	0.94	3.7	5.2°C	9.5	8	46.2°C	Facultative anaerobe***
Shigella spp.	0.96	4.8	6.1°C	9.3	5.2	47.1°C	Facultative anaerobe***
Staphylococcus aureus-growth	0.83	4	7°C	10	25	50°C	Facultative anaerobe***
Staphylococcus aureus-toxin	0.85	4	10°C	9.8	10	48°C	
Vibrio cholera	0.97	5	10°C	10	6	43°C	Facultative anaerobe***
Vibrio parahaemolyticus	0.94	4.8	5°C	11	10	44°C	Facultative anaerobe***
Vibrio vulnificus	0.96	5	8°C	10	5	43°C	Facultative anaerobe***
Yersinia enterocolitica	0.954	4.2	-1.3°C	10	7	42°C	Facultative anaerobe***

* requires limited levels of O_2, ** requires the absence of O_2, *** grows either with or without O_2.

Sources: http://www.cfsan.fda.gov/~mow/intro.html (FDA, USA)

C. Physical hazards

Physical hazards are extraneous matter or foreign objects and include any physical matter not normally found in food which may cause illness (including psychological trauma) or injury to an individual (Corlett, 1991). The FDA maintains a passive surveillance system known as the Complaint Reporting System for the reporting of consumer complaints related to food items. A total of 10,923 complaints regarding food items consumed during the period of October 1, 1988, to September 30, 1989, were reported to the FDA Complaint Reporting System (Hyman and Tollefson, 1991). The largest single category (2,726 complaints) involved the presence of foreign objects in food and accounted for 25% of all complaints. Of all reported foreign object complaints, 387 (14%) resulted in illness or injury. The most common foreign object in those reports was glass. One reason physical hazards are the most often reported complaint is that foreign objects provide tangible evidence of a product deficiency. Food processors should, therefore, be aware of product adulteration by physical substances and address their control in an appropriately designed hazard control system.

2.2.2. Factors affecting the growth of pathogens in food

Microbes need water, nutrients and appropriate conditions of temperature and pH in order to multiply. The ability of foodborne disease agents to grow and multiply or to produce toxins sufficient to cause illness usually depends on a number of factors including pH, water activity (*aw*) and temperature. Accordingly, the shelf-life of foods can be increased by varying these three factors, i.e. heating for enough time to kill hazardous microorganisms, removing water by drying or rendering it unavailable for microbial growth by the addition of solutes, reducing the storage temperature, or reducing the pH, either by the direct addition of acid or by fermentation. Some of these processes were practised in ancient times to preserve foods from times of plenty to times of scarcity, as cited in ICMSF (1988). A brief discussion of these factors follows.

A. pH and acidity

Mortimore and Wallace (1998) discuss the role of acidity as a preserving factor in food products. Fermenting and acidifying foodstuffs are food preservation techniques that have been used for thousands of years.

There is a characteristic pH range across which microorganisms can grow and the limiting pH for growth varies widely between different species, as reported by FDA (1992). Most microorganisms grow best at around neutral pH 7, but may also grow at values ranging from pH 4 to pH 8. A small number of bacteria can grow at pH < 4 or pH > 8 but those able to grow at pH < 4 are not normally associated with food poisoning, according to FDA. However, the growth of these acid-tolerant organisms can have food safety implications if their growth in the foodstuff is involved in raising the pH to a level where other microorganisms, including pathogens, can grow. This is true for yeasts and moulds which can grow at pH values considerably lower than pH 4.

Mortimore and Wallace (1998) note that microorganisms may survive at pH values outside their range for growth. This has implications for food safety when other factors cause the pH to change. For example, the spores of *Bacillus cereus* might be present in a low-pH raw material where they are unable to grow. If this is then mixed with other raw materials to make a higher-pH product, the spores may be able to germinate and grow to dangerous levels.

B. Temperature

Microbial agents occurring in a food must be able to survive temperatures at all stages of the process to be able to cause illness. Temperature values which induce microbial growth have both minimum and maximum ranges, and an optimum level for maximal growth. The FDA (1994b) describes the terminology used to classify microbes with respect to temperature. For example, psychrotrophs survive at low temperatures (0°C to 25°C) and thermotrophs survive at high temperatures (40°C to 80°C).

Most bacteria grow and multiply very rapidly at the normal human body temperature of 37°C (98.6°F). Increasing the temperature to about 63°C (145°F) slows their growth, and temperatures above this level may destroy them. The length of time and temperature required to kill pathogenic microbes depend on the type of organism and the food in question. At 100°C in water, many bacteria will be destroyed within a few minutes, but spores can survive. Spores may need to be exposed to temperatures of over 121°C (250°F) for several minutes before they are affected. Such temperature levels may, however, fail to destroy bacterial toxins (Trickett, 1992). Most bacteria are not killed at low temperatures, but only remain dormant, so that when the food is removed from refrigeration and warmed up, the rate of growth increases.

C. Water activity

Water activity (*aw*) is a measure of the availability of water in a sample (ICMSF, 1988). It is the ratio of the water vapour pressure of the sample to that of pure water at the same temperature. As microorganisms can only grow in the presence of an available form of water, they can be controlled by controlling the *aw*.

Traditionally, *aw* has been used as a preservative factor against microorganisms in foods through the addition of salt and the reduction of moisture content through drying. Salt has wide application in products such as pickled, salted fish and dry cured meats. In Oman, for example, drying has been used to preserve sardines to be used for human consumption, animal feed or soil fertilisation.

Although each of the factors discussed above plays a significant role, the interaction between them determines whether or not a microorganism will survive and grow in a given food. Whilst the results of such interaction are often hard to predict, advantage could be taken of this interaction in preventing the growth of pathogens in foods. For example, according to FDA (1994b), a food with a pH of 5.0 (within the range for the growth of *Clostridium botulinum)* and a water activity of 0.935 (less than the minimum for the growth of *C. botulinum*) may not support the growth of this organism.

Foods most likely to cause human illness, as reported by Buzby and Roberts (1996), are high protein, non-acid foods such as meat, poultry, seafood, dairy products, and eggs, all of which are widely available in Oman. Either the animal can be the source of contamination or cross-contamination, or, less likely, human food handlers can contaminate the animal product. Pathogen contamination can occur in any part of the food chain, starting with feed and other farm inputs. Contamination of food at any point in the food chain can be traced to one or a combination of microbial, chemical or physical agents.

Unfortunately, there are, as yet, no empirical data on the causes of foodborne illnesses in Oman. An important recommendation of the current study is that (a) a system for monitoring foodborne illnesses in Oman needs to be established so that policy makers have access to an appropriate data-set; and (b) analytical services need to be radically improved (see Chapter Five).

In conclusion, the contamination of live fish with bacteria normally found in the environment obviously cannot and need not be controlled (that is, it is a hazard with very low or no risk at all). However, contamination with bacteria from the animal/human reservoir can be limited by monitoring the fishing areas and control of fishing if gross pollution from population centres or industry is evident, as recommended by WHO (1995). Also important, however, is the monitoring of the fishing areas for the presence of parasites and biotoxins (toxic fish or toxic marine plankton).

Generally the growth of bacteria can be controlled by strict temperature control. A temperature < 3°C is a CCP for all pathogens (Huss, 2000) and histamine production at all stages from catch to distribution of the final product. Monitoring of time/temperature conditions during handling and processing can be done by date marking of boxes and containers and by visual inspection of icing and chilling conditions. Time and temperature recording at specific points and during processing should, therefore, be controlled. Process flow should be designed to avoid stops and interruptions, and all chill rooms should be supplied with thermometers. Visual inspection and control checks of temperature should be done as a daily routine. This recommended approach is consistent with the recommendations of Commission Decision 94/356/EC.

The preventive measures for post-harvest contamination are GMP, effective hygiene and sanitation programmes, well constructed factories as outlined in the Sanitation Standard Operation Procedures (SSOP) and the "prerequisites" as required by the USA

(Federal Register, Vol. 60 No.242, 1995 part 123), the steps summarised in EU Council Directive 91/493/EEC and as specified by the Codex Alimentarius (FAO/WHO, 1997).

Finally, the safety of foods should be not only focus on hygienic processing only, but on factors which reduce growth rate of potentially hazardous microorganisms. Much more attention should be paid to the role of temperature, water activity, pH, other preservative compounds and the interaction between these parameters in assuring food safety. A full understanding of the ecology of the biological disease agents and their behaviour in the various food products is also needed to obtain major improvements in controlling foodborne illness.

2.3. Hazard Analysis Critical Control Point (HACCP) Systems

Food may become contaminated at any stage of the food chain, from primary production to processing and handling before consumption. For this reason, the causes of foodborne diseases are complex and interdependent. But there is acceptance (WHO, 1990, Commission Decision 94/356/EC) that application of the hazard analysis critical control point system, with the help of food safety education and training of food handlers and the public, is an effective means for the prevention of foodborne diseases. The application of HACCP to food safety control is based on identifying potential food hazards and faulty practices which can be detected in production, processing, packaging, or preparation of food, leading to measures to prevent or minimise risks to consumers.

The concept of HACCP was formally brought into food law in the European Union (EU), following adoption of the EU Food Hygiene Directive (93/43/EEC) in June 1993 (Goulding and Stroud, 1996) and reinforced for fishery products in Commission Decision 94/356/EC. Under the Directive, food business operators are required to identify steps in their processes and activities that are critical to securing food safety and to ensure that adequate preventive procedures are identified, implemented, maintained and evaluated based on the principles of HACCP. Member States were required to implement the directive no later than mid December 1995. In the UK, HACCP implementation took place in September 1995 (Mortimore and Wallace, 1998). The introduction of the HACCP system in Oman came in 1998 after EU countries banned import of fishery products that were not produced in accordance with the earlier Council Directive No. 91/493/EEC, qualified by the Commission Decision referred to above.

2.3.1. Historical development of HACCP system

The HACCP system is the consequence of extensive research work done over the past three decades by both industry and academia. The research work on the HACCP system started in 1959 when the Pillsbury company was asked to produce a food that could be used under zero gravity conditions in space capsules. As the space race was a high priority in the American administration's agenda at that time, it was necessary to design food for astronauts which was safe to use under zero gravity conditions. Pillsbury was the food company responsible for developing astronauts' first food, alongside the National Aeronautic and Space Administration (NASA) and the US Army Natick Laboratories (Bauman, 1974; Corlett, 1989; Bauman, 1990; Bauman, 1992; Savage, 1995).

Bauman (1990) states that the most difficult part of the task was to come as close to 100 percent assurance as possible that the food products produced for space use would not be contaminated with bacterial or viral pathogens, toxins, chemicals, or physical hazards that could cause an illness or injury. Such hazards might result in an aborted or catastrophic mission.

Pillsbury recognised that by using existing techniques of quality control, 100 percent safety assurance was inaccessible. Moreover the amount of testing that had to be done to arrive at a reasonable decision point as to whether a food was acceptable was extremely high. A large part of the production of food had to be utilized for testing, leaving only a small proportion available for the space flights. This brought into question the current system of quality control that was being used in the food industry as a whole. Most quality assurance programmes were based on what the quality assurance manager believed was a good programme. There was no uniformity of approach in the food industry as to what constituted a good system.

Pillsbury believed that if it was possible to develop a prevention system of control, together with proper record keeping, it would be possible to produce food with a high degree of safety assurance. Meanwhile, the company was required by NASA to keep records that allowed traceability of the raw materials they used, the plant where the food was produced, the names of people involved in the production and any other information that might contribute to the history of the product; in other words, a mechanism for tracing problems back to the source. Using this approach, the HACCP concept was born.

The Hazard Analysis element of HACCP involves a systematic study of ingredients, food products, conditions of processing, handling, storage, packaging, distribution and consumer use. This analysis allowed Pillsbury to identify the sensitive areas that might contribute to a hazard. From this information, Critical Control Points in the system were determined. The system, when properly applied, can be used to control any area or point in the food chain that might contribute to a hazardous situation, whether it be contaminants, pathogenic microorganisms, physical objects, chemicals or raw materials (Bauman, 1990; Bauman, 1992).

In order to develop the hazard analysis part of the system, Pillsbury adopted a system of analysis called "Failure, Mode, and Effect Analysis" (FMEA) used by US Army Natick Research, Development, and Engineering Centre Laboratories for medical supplies (Bauman, 1974; Bauman, 1990; Bauman, 1992; Savage, 1995). The method consists of examining the product and all the components and the processes used to make it, and asking what could possibly go wrong at each stage in an operation, along with possible causes and the likely effects, before deploying effective control mechanisms (Bauman, 1974; Mortimore and Wallace, 1994). Like FMEA, HACCP examines hazards, and detects those sensitive areas and ingredients which have to be controlled to ensure that hazards are not brought into the plant.

The HACCP system was first exposed to the public during the 1971 National Conference on Food Protection (U.S. Dept. HEW, 1972). Following this conference, Pillsbury was granted a contract by FDA to conduct classes for FDA personnel on the HACCP system. The Pillsbury Company published the first comprehensive document on HACCP in 1973. This represented an important landmark in the development of a modern food safety methodology (Bauman, 1992).

After Pillsbury's introduction of HACCP to the food industry, four federal agencies, the National Marine Fisheries Service (NMFS), the Food Safety and Inspection Service (FSIS), the Food and Drug Administration (FDA), and the U.S. Army Natick Research and Development Centre, asked the National Research Council to organise a panel of experts to formulate general principles for the application of microbiological criteria for foods. A Food and Nutrition Board Subcommittee on Microbiological Criteria was then established in 1980 (Savage, 1995). The Subcommittee's report recommended the adoption of the principles of HACCP (as advised by the Pillsbury Company in 1971) and the formation of a Commission on Microbial Criteria for Foods (now known as the National Advisory Committee on Microbiological Criteria for Foods (NACMCF). In 1988 the International Commission on Microbial Specifications for Foods (ICMSF) developed its own HACCP approach to ensure the microbiological safety and quality of foods (ICMSF, 1988).

NACMCF was created in November 1989. One of its first tasks was to write a document setting out the HACCP principles. The Committee further refined the HACCP concept by adding to the principles of HACCP descriptions of what each principle involved. The HACCP document of the Committee (NACMCF, 1989) and their future revisions (NACMCF, 1992; NACMCF, 1998) represent milestones in HACCP development, in that they aim to reinforce consistency in the use and application of the HACCP principles and definitions (Bauman, 1992). The main difference between the NACMCF and ICMSF was that the former emphasised the importance of record keeping as a separate principle (Savage, 1995). Moreover, the ICMSF considered both safety and quality (including non-safety regulatory factors) parameters in HACCP systems, whereas the NACMCF specifically recommended that formal HACCP programmes be restricted to safety concerns only (Buchanan, 1990; Tompkin, 1990).

At their June 14, 1991 meeting, the Codex Committee on Food Hygiene HACCP Drafting Group developed a draft report on HACCP (Codex, 1991). Subsequently, in October 1991, the Codex Committee on Food Hygiene made minor revisions and requested that the report be circulated to member countries for comments. The final document, entitled "Guidelines for the Application of the Hazard Analysis Critical Control Point (HACCP) System", was adopted by the 20th Session of the Codex Commission in 1993. The Guidelines were sent to all Member Nations and Associate Members of FAO and WHO as an advisory text. It was then for individual governments to decide what use they wished to make of the Guidelines (Codex, 1993). The Codex document contained a logical sequence of steps for the application of HACCP and introduced a decision tree to identify Critical Control Points (CCPs) at each step. In response to the 1991 draft the NACMCF reconvened a HACCP Working Group. The primary purpose was to review the Committee's November 1989 HACCP document, comparing it with the Codex draft.

Another milestone in the development of HACCP is its evolution towards becoming mandatory. In 1973 the FDA included HACCP in the GMP regulations for low-acid canned foods. The NACMCF and ICMSF principles were then designed to enable non-retorted food operations to take advantage of the same preventive approach used for canned food (Corlett, 1989; Savage, 1995).

Following the publication of the NACMCF, ICMSF and the Codex documents, the use of HACCP principles in the food industry expanded to other sectors, such as food services, refrigerated foods, dairy products, seafoods, red meat, and poultry. New regulations strengthened HACCP implementation in both the US and Europe. Thus, by 14 December 1995, all food businesses in the European Union were required to have in place an effective HACCP system, according to the Council Directive 93/43/EEC on the Hygiene of Foodstuffs. In the US, HACCP is now mandated for meat, poultry and seafood plants, and soon also for fruit and vegetable juice and egg processes (Morris, 1997; De Beer and McLachlan, 1998). Thus, seafood processing plants and storage warehouses were required to operate under HACCP regulations on December 18, 1997. Enforcement of HACCP in red meat and poultry companies was based on plant size; for instance, large plants (>500 employees) were required to implement HACCP by January 26, 1998; smaller plants (>10 employees) by January 25, 1999; very small plants (less than ten employees or $2.5 million annual sales) by January 25, 2000.

The Uruguay Round Negotiations under the General Agreement on Tariffs and Trade (GATT) also resulted in a further push on the utilisation of HACCP world-wide, recommending the adoption of the international guidelines proposed by Codex Alimentarius Commission.

2.3.2. HACCP principles and concepts

Different interpretations and applications of HACCP systems have been made during the past years, along with improvements in microbial isolation. However, the general meaning of the system remains very close to the concept first developed by Pillsbury.

The HACCP concept was described by Pillsbury as a preventive system of control, particularly with regard to microbial hazards. The hazard analysis process consisted of three main activities:

- identification of ingredients by ranked classes of food ingredients in hazard categories based on the risks that they bear (Table 2.2), then evaluation of ingredients considering historical evidence as to whether or not they can support bacterial growth;
- critical process points. Pillsbury suggested two critical components to the process, biological critical process points which, if not maintained within certain parameters,. can result in the production of food which may be unsafe from a microbiological standpoint; and physical hazard control points, defined as elements of process equipment or the environment of a process which, if not properly maintained and monitored, can result in the introduction of hazardous foreign materials into a product; and
- relevant human factors. As they affect product safety, the evaluation of consumer practices, as an essential part of HACCP plans, was also proposed by the Pillsbury Company.

However, the concept of human factors (above) was never taken up in future versions of the HACCP plans and it was not until the nineties, when epidemiological studies linked homes and food poisoning, that HACCP experts reconsidered again the importance of consumer abuse.

Table 2.2. Pillsbury company HACCP principles (from Savage (1995))

- No.1. Identification and assessment of hazards associated with the growing, harvesting, processing- manufacturing, marketing, preparation, or use of a given raw material or food product.
- No.2. Determination of Critical Control Points at which identified hazards can be controlled.
- No.3. Establishment of procedures to monitor critical control points.

Critical control points were those processing determinants whose loss of control would result in an unacceptable food safety risk (Table 2.3). The hazard analysis proposed by Pillsbury considered the evaluation of ingredients, the processing steps, and the potential for consumer abuse of the product.

Table 2.3. Hazard categories[a] proposed by the Pillsbury company (Bauman, 1974)

- Foods intended for special populations: such the elderly and infants.
- Sensitive ingredients: which can have a pronounced effect on food safety (e.g. eggs).
- Compound ingredients: which contain 30% or less of sensitive ingredients.
- Ingredients of agricultural use: not previously considered to be a source of microorganisms, chemicals or pesticide residues (e.g. wheat, starches).
- Ingredients historically free of pathogens or residues: such sugar, salt ...etc.

[a]ranked in descending order of risk

In summary, Pillsbury's pioneering work developed a HACCP concept which does not differ greatly from the current HACCP concept. Although considering biological hazards as priority, Pillsbury also evaluated the risk of chemicals and physical hazards. Further, it acknowledged that risk could come from the ingredients, processes and consumer abuses. Above all, the first HACCP system was based upon control rather than prevention of risks. It provided a ranking system to help in the hazard analysis, but it lacked a clear and systematic protocol to identify critical control points, and to monitor and verify the system.

2.3.3. The modern HACCP

A modern statement of HACCP is the current version adopted by the Codex Alimentarius Commission in June 1997 (Codex, 1997a) and by NACMCF in August 1997 (NACMCF, 1998): see Table 2.4. These new documents have a similar structure to the previous versions of the HACCP system. However it should be noted that both documents omit the use of words like "risk" and "risk assessment" in order to avoid confusion between HACCP and other systems such as risk analysis (WHO, 1995a).

The NACMCF document updates the 1992 document (NACMCF, 1992) using, as a point of comparison, the 1997 HACCP guidance prepared by Codex. Based on its review, the Committee made the following changes: (a) more concise HACCP principles, revised and added definitions; (b) sections on prerequisite programmes, education, training, and implementation and maintenance of the HACCP plan; (c) revised and a more detailed explanation of HACCP principles, and; (d) a decision tree for identifying critical control points.

The novelty of the NACMCF is a description of prerequisite programmes, including Good Manufacturing Practices that address operational conditions providing the foundation for the HACCP system.

Table 2.4. The modern HACCP principles (NACMCF, 1997; Codex, 1997a)

- No. 1: Conduct a hazard analysis
- No.2: Determine the critical control points (CCPs)
- No.3: Establish critical limits
- No.4: Establish monitoring procedures
- No.5: Establish corrective actions
- No.6: Establish verification procedures
- No.7: Establish record-keeping and documentation procedures

Hazard analysis (Principle 1) follows the same format as the 1995 version. However, instead of referring to preventive measures, it considers control measures. This change responds to the fact that not all hazards can be prevented but almost all can be controlled (NACMCF, 1998). Hazard analysis requires the identification of hazards and the evaluation of hazards in terms of severity of the potential hazard and its likely occurrence. As in the previous document (NACMCF, 1992), high levels of technical expertise and information are required to determine the likelihood and severity of hazards in foods.

Above all, modern HACCP is based on principles which require qualified personnel who have or understand technical information, enabling them to fulfil the several requirements behind each principle.

In 1993, the Joint FAO/WHO Codex Alimentarius Commission endorsed the HACCP system as the most cost-effective approach devised to date for ensuring the safety of food (Motarjemi et al., 1996). Experiences gained in some countries indicate that the application of HACCP systems leads to more efficient prevention of foodborne diseases. For example, in the USA, application of HACCP by fish processors is estimated to avert some 20-60% of cases of sea foodborne illnesses (FDA, 1994b). The HACCP system has a variety of applications:

- The HACCP system assures food consumers that the food they buy is safe to eat. The HACCP system can be employed as a tool for food control. With care it can be more efficient than traditional systems.
- The study of food preparation practices can be assisted by the HACCP concept. It identifies and assesses hazardous behaviour, which might be the focus of health education interventions.
- The HACCP idea can be used as a tool for the management of food safety programmes to identify those problems which are of greatest risk to public health, and in order to prioritise interventions.

From the literature noted above the additional benefits of the HACCP system can be summarized as follows:

- It eliminates some of the problems associated with traditional approaches to food safety control (generally based on "snap-shot" inspection and end-product testing), including: the difficulty of collecting and examining sufficient samples to obtain statistically valid data; the time required to obtain results; the high costs incurred by end-product testing, or in the event of product recall, when contamination might have occurred; identification of problems without understanding the causes; and limitations of "snap-shot" inspection techniques in predicting potential food safety problems.
- The HACCP system has the capacity to predict most hazards, even where failures have not previously been experienced. It is therefore particularly helpful for new operations.
- The HACCP system accommodates changes introduced, new equipment, changes in procedures and other technological developments.

- The HACCP system helps to direct resources to the most critical part of the food operation.
- HACCP lays the foundation for a better relationship between food processors and the inspection services. The system provides a transparent framework that all reasonable precautions have been taken to prevent a hazard from reaching the consumer. In this way, it encourages confidence in the safety of food products and thus promotes both confidence in the food industry and stability of food businesses.
- The relationship between consumers and producers can also be improved because the latter have more confidence in the safety of offerings.
- Audit is an important feature for food buyers and is greatly facilitated.
- It is an important component of the various requirements food exporting countries need to observe when selling fish on world markets, hence its incorporation into the criteria applied by European Commission teams when testing observance of Council Directive 91/493/EEC and Commission Decision 94/356/EC.

2.4. The Working HACCP System

HACCP has become widespread in recent years. Although the HACCP concept has been around in the food industry for some time, it is still in the process of evolving (Bauman, 1990). One of the most important recent developments is the growing emphasis on the traceability of product back to sources. This section of the literature review focuses on HACCP as an instrument for implementing a preventive operation involving personnel, the product and the process.

2.4.1. HACCP as a philosophy and as a tool

Mitchell (1992) and Mortimore and Wallace (2001) have used the term "philosophy" to describe HACCP. They mean by this a set of ideas which informs the actions of all the people working in this business. This requires knowledge of the system, commitment, planning, resources and follow through. Thus, implementation of a HACCP philosophy in this sense takes time.

The implementation of HACCP involves adjustments in the operation itself, and also in personnel attitudes and behaviours towards food safety. Another important aspect is that every level of staff is involved in contributing to the end product, including non-technical personnel. Communication is important for the success of establishing an effective system. These authors emphasise that everybody, not only those directly involved in the implementation of HACCP, must be made familiar with the system and feel ownership of it. Managerial actions necessary to initiate the HACCP philosophy are to: (a) gain management commitment (Corlett, 1992; NFPA, 1993; Codex, 1997a;

NACMCF, 1998); (b) develop HACCP policy and objectives (Corlett, 1992); (c) develop the HACCP plan; (d) assign specific responsibilities to persons and groups (Corlett, 1992); and (e) develop prerequisite programmes (NACMCF, 1998).

2.4.2. Prerequisite programmes

A number of definitions have been proposed for prerequisites. The Canadian Food Inspection Agency (1998) suggests "universal steps or procedures that control the operational conditions within a food establishment allowing for environmental conditions that are favourable for the production of safe food". This definition has also been used by the UK Expert HACCP Steering Group (1999) which adds the examples: a premises programme, sanitation and pest control and an equipment programme.

The US National Advisory Committee on Microbiological Criteria for Foods (NACMCF, 1997, p3) defines prerequisite programmes as "Procedures, including Good Manufacturing Practices, that address operational conditions providing the foundation for the HACCP system". The European Commission also encourages the use of "guides of good manufacturing practice drawn up by appropriate professional organizations and acceptable to the to the competent authorities" (Article 1 Commission Decision 94/356/EC).

The Codex Alimentarius Commission states: "Prior to the application of HACCP to any sector of the food chain, that sector should be operating according to these general principles along with appropriate Codex Codes of Practice and appropriate food safety legislation". In other words, these are seen as prerequisites to HACCP (Codex, 1997a, b).

The World Health Organisation has also published a definition for prerequisites (WHO, 1999): "Practices and conditions needed prior to and during the implementation of HACCP and which are essential for food safety" and again mentions that these are described in the Codex Alimentarius Commission's General Principles of Food Hygiene and other Codes of Practice.

Mortimore and Wallace (1998) describe prerequisites as the HACCP Support Network (see Figure 2.1). This shows the inter-relationship of management systems and procedures in any food business for the production of safe, high quality products.

Generally, "prerequisite" is the term used to describe systems that must be in place in order to support the HACCP System (e.g. Supplier Quality Assurance, Good Manufacturing Practice). The name "prerequisite" applies because these are normally systems in place before the HACCP Plan is developed, although they may also form part of the HACCP plan.

Prerequisite programmes include elements previously, and still frequently, described as GMP (e.g., cleaning, operator and environmental hygiene, plant and building design and preventive maintenance). These concepts have been employed by the food industry for many years. GMP has long been considered as a support programme that provides foundations for HACCP in an overall food safety management programme (Sprenger, 1995). Indeed, the European Council defined many features of typical prerequisites in the Annex to its Directive 91/493/EEC (see Chapter Three). What is new to many companies is the concept of making prerequisite programmes work alongside HACCP to control general hygiene and quality issues. Prerequisite programmes are summarised in Figure 2.1.

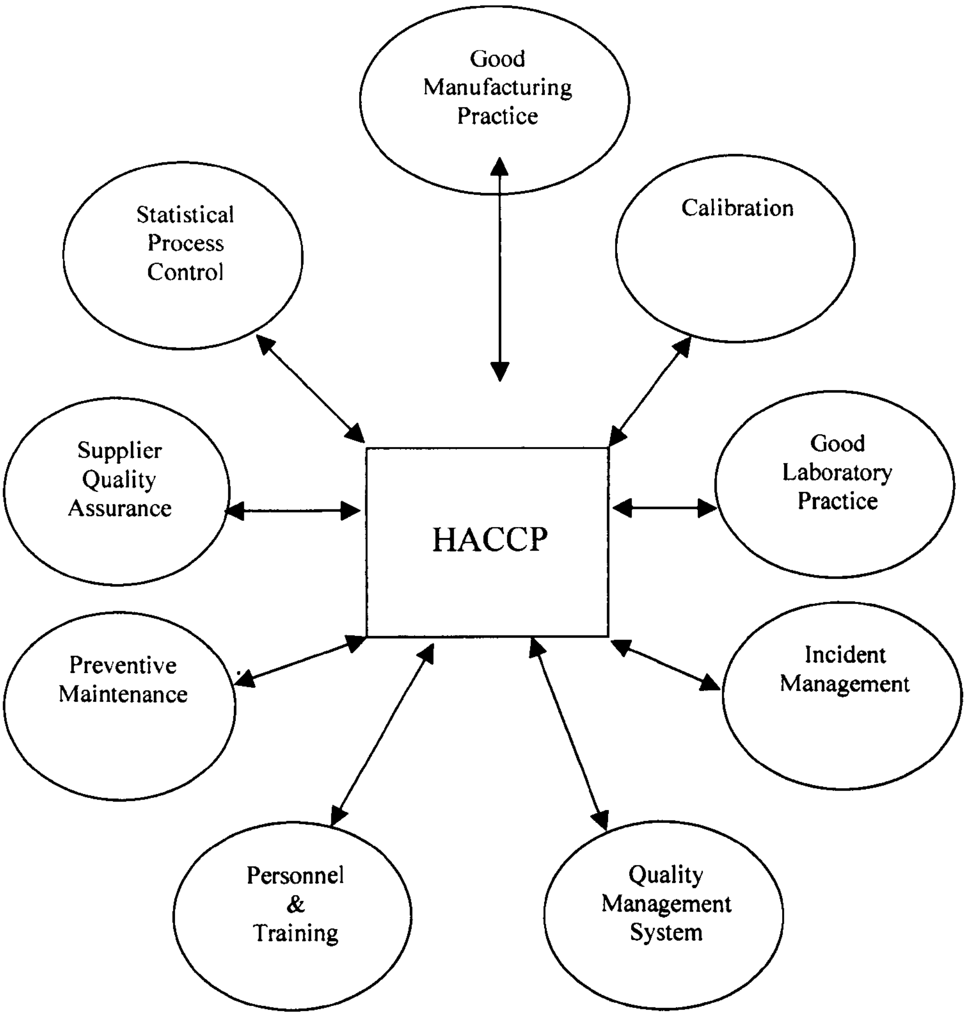


Fig.2.1. The HACCP support network (Mortimore and Wallace, 1998)

According to Mortimore and Wallace (1998) common prerequisite programmes may include, but are not limited to:

Layout

The layout of the facility is designed to minimize cross-contamination. Segregation of raw materials from finished products, including all required services and facilities for the manufacture of the product, is important. Issues include the availability of potable water, and adequate cleaning facilities for plant, equipment and the environment where it is located, along with the connection of all required services in the correct area (e.g., steam heating and cooling facilities). The number of holding stages and associated times should also be considered because these provide opportunities for contamination. Adequate space for holding the required amount of product at each stage without causing a cross-contamination risk, and the availability of appropriate temperature-controlled facilities are necessary. The patterns of movement of staff and equipment should be considered, with the provision of adequate hygiene facilities, including changing and rest rooms and hand-washing stations, along with canteens and recreational facilities.

Buildings

Mortimore and Wallace (1998) note that the building structure may be a possible safety risk to the product, through harbourage of pests and contaminants, or through physical contamination due to its design and maintenance. Non-porous and easy to clean surfaces, with all cracks filled and sealed, and overhead services are recommended. Regular maintenance of buildings is required to prevent physical hazards falling into the product, and the clearing of drains should take the flow away from production areas, with no chance of back flow or seepage. Pest proofing and cleaning schedules are also part of prerequisite programmes.

Equipment

Cross-contamination risk can be avoided by well-designed equipment. Problems might arise through parts of the equipment breaking off and entering the product as physical hazards. If equipment is difficult to clean or is poorly cleaned, microbiological build-up could contaminate the product. Chemical contamination could result from lubricants or cleaning residues remaining on the food-contact surfaces.

People

Food handlers and other personnel with access to the food processing area might contaminate the product with microbiological, chemical or physical hazards. The process layout, movement patterns and training programmes should take this into account.

Cleaning

Appropriate cleaning schedules are an important prerequisite. Points of importance include the proper labelling of containers, the avoidance of food containers for chemicals and training in safe use.

Raw materials

Raw materials can act as cross-contaminants if they gain access to the wrong product, or if they are part of a product and added in excess quantities. This may be serious in the case of sensitive raw material used in a product in unknown qualities.

Storage

Storage areas include segregation, temperature and humidity control, and pest proofing.

Products

Residues of other products can affect the main product and cause a serious hazard if allergenic. Issues include the special separation of production lines, handling and cleaning procedures.

In some countries there is already some formalisation in the use of prerequisites. For example in North America the US Department of Agriculture Food Safety Inspection Service (USDA-FSIS) requires not only HACCP, but also GMP and Standard Sanitation Operating Procedures (SSOPs) for meat, poultry and egg producers. Similarly, the FDA requires the prerequisite of GMP for all food producers and lists HACCP as a specific requirement for seafood production. Canada's prerequisites list six essential areas, covering premises, receiving/storage, equipment performance and maintenance, personnel and training, sanitation and pest control and recalls (Canadian Food Inspection Agency, 1998). In the UK, Food Safety (General Food Hygiene) Regulations 1995 (UK SI, 1995b) that implement the EC Hygiene Directive of 1993

(Council Directive 93/43/EEC) contain characteristic prerequisite requirements. These concepts of prerequisite programmes are not new to the food industry or to regulators around the world, although the term "prerequisites" may not always have been used.

The objectives of the prerequisite programmes are: (a) to provide the basic environmental and operating conditions that are necessary for the production of safe, wholesome food (NACMCF, 1998); (b) to be a precondition to the development and implementation of HACCP. HACCP will fail if they are insufficient (Notermans et al., 1994; 1995a; 1995b; Mortimore and Wallace, 1998). NACMCF (1998) argues that the implementation of prerequisite programmes has the effect of limiting the scope of HACCP strictly to food safety.

2.4.3 The three stages of HACCP

HACCP plans are not restricted to the seven principles noted in section 2.3 of this review. In fact there are three clear stages of HACCP. These are pre-HACCP, application of HACCP and post-HACCP.

A. Pre-HACCP

Pre-HACCP includes a range of preliminary tasks which are carried out before the application of the seven principles. The main purposes of these tasks are to establish: (a) the management of the HACCP system; (b) the responsibilities upon the system and (c) the scope of the HACCP plan. A HACCP plan is the written document that is based on the principles of HACCP and that defines the procedures to be followed (NACMCF, 1998). It represents the outline for the company product-specific food plant HACCP system (Corlett, 1992).

Preliminary tasks were suggested in the Codex Alimentarius document in 1993. In the HACCP document prepared by NACMCF the preliminary tasks are: (a) assemble the HACCP team; (b) describe the food and its distribution; (c) describe the intended use and consumers of the food; (d) develop a flow diagram that describes the process and (e) verify the flow diagram (NACMCF, 1998). These are discussed in detail in the following section.

Assemble the HACCP team

A HACCP team is defined as the group of persons charged with responsibility for developing, implementing, maintaining and record keeping for the HACCP system. The team is recommended to be multidisciplinary (NFPA, 1993; Codex, 1997a; NACMCF, 1998; FAO, 1998, Commission Decision 94/356/EC) and authors typically recommend the inclusion of plant personnel from production, sanitation, quality assurance, laboratory, engineering, inspection, and food microbiology. The team should also include local personnel, because they know the limitations of the facility, equipment, people and other factors (Tompkin, 1990). FAO (1998) suggests that the personnel selected should have a basic understanding of:

- technology and equipment used on the processing lines;
- practical aspects of the food operations;
- the flow and technology of the process;
- applied aspects of food microbiology;
- HACCP principles and techniques.

Ideally, the team should not be larger than six, although for some stages of the study it may be necessary to enlarge the team temporarily with personnel from other departments, e.g. marketing, research and development or purchasing and finance as suggested by FAO (1998). The European Commission suggests that the team consists of a quality control specialist, a production specialist, a technician and a person with specialist knowledge of microbiology, hygiene and food technology (Annex to Commission Decision 94/356/EC). The NACMCF (1998) document suggests that the HACCP team may need external technical assistance in order to help in the hazard analysis process. Such individuals should have the knowledge and experience to correctly:

- conduct a hazard analysis
- identify potential hazards
- identify hazards that must be controlled
- recommend controls, critical limits, and procedures for monitoring and verification
- recommend appropriate corrective actions when deviation occurs
- recommend research related to the HACCP plan if important information is not known
- validate the HACCP plan.

In Oman, and probably in other developing countries, the HACCP team may find it difficult to develop a HACCP plan as most of these medium and small businesses may have few, if any, experienced, technically trained people who can identify and assess hazards, and have the technological know-how to develop a HACCP programme. At the same time, they may lack the financial resources to use external specialists and the capacity to release employees to spend time at training courses.

Describe the food and its distribution

Authorities (e.g., NFPA, 1993; Commission 1994, Codex, 1997a; NACMCF, 1998; FAO, 1998) recommend that the HACCP team make a thorough description of each food product, including all ingredients, processing methods, packaging materials, etc. used in its formulation to assist in the identification of all possible hazards associated with the product. The product description should include the name of the product, ingredients and composition, potential to support microbial growth (*aw*, pH, etc.), brief details of the process and technology used in production, appropriate packaging and any special handling required during ingredient receipt, processing, product storage and distribution, retail display preservation requirements during distribution (frozen, chilled, ambient). This requirement presents no major difficulties for simple fish products originating in Oman.

Describe the intended use and consumer of the food

According to the literature (Codex, 1993; Mortimore and Wallace, 1998; Moy et al., 1994) this step is designed to establish the intended use of the product by the consumer target group (e.g. infants, elderly, immuno-compromised). It is important to define the normal use by the consumer and also possible abuse of the product as far as it is within the control range of the producer. This is not so easy for Oman producers, or indeed for any distant developing countries, because of a lack of detailed market knowledge (Chapter 1.3 of Annex to Decision 94/356/EC refers).

Develop a flow diagram

The purpose of a flow diagram (Chapter 1.4 of Commission Decision 94/356/EC) is to provide an outline of the steps involved in the process and is not seen as a major obstacle for Omani food producers. The flow diagram is intended to depict all the steps in the process, from raw materials to end product, which are directly under the control of the business. The following types of data should be included, as recommended by Mortimore and Wallace (1998):

- information on all raw materials and product packaging, including format on receipt and required storage conditions;
- process activities, including the scope for any lags in the system;
- details of temperature and time for all stages. This is important for analysis of microbiological hazards;
- types of equipment and design features;
- details of any product reworking or recycling loops;
- profiles of floor plans with details of segregated areas and personnel movements. Whilst it is possible to indicate process flow and floor plan on the same diagram, HACCP teams often find it helpful to keep these as two distinct diagrams in the HACCP plan;
- storage conditions, including location, time and temperature;
- distribution/customer issues.

The Commission adds the segregation of clean and dirty areas, the hygienic environment of the establishment, personnel routes and hygienic practices to desirable constituents of the flow diagram. (Chapter.1.4 of Decision 94/356/EC).

In addition, the flow diagram may include steps in the food chain, which are before and after the processing that occurs in the plant. Bryan (1992) recommends that the flow diagram need not be as complex as engineering drawings. It is easier to identify routes of potential contamination, to suggest methods of control and to discuss these among the HACCP team if there is a flow diagram. The review of the flow of raw materials from the point at which they enter the plant, through processing to departure is the feature that makes HACCP a specific and important tool for the identification and control of potential hazards.

Verify the flow diagram

The HACCP team should perform an on-site review of the operation to verify the flow diagram. This is also not seen as a major hurdle in Oman. When the flow diagram is complete the HACCP team prior to the hazard assessment stage should verify it. This involves team members watching the process in action to make sure that what happens is the same as what is written down, and may also involve going in on the night shift or weekend shift to ensure that any alternatives are included. It is essential to get the flow diagram right, as the hazard analysis and all decisions about CCPs are based on these data.

B. The application of the HACCP principles

This is the second stage and after the preliminary tasks have been completed, the seven principles of HACCP can be applied. A review of each principle individually will be discussed comparing the modern HACCP documents together with recent publications.

Principle 1: Conduct a hazard analysis

The Commission refers to this principle as "identification of hazards, analysis of risks and determination of measures necessary to control them" (Annex to Commission Decision 94/356/EC). Knowledge of food science and HACCP is necessary for the performance of a satisfactory hazard analysis (FAO, 1998). The present study identifies the weakness of the knowledge base as an important barrier for Oman. The purpose of hazard analysis is to identify potential problems which could occur in an operation. More than one hazard may be associated with a step in an operation. Reflection on each hazard is required and controls need to be established to minimize or prevent its occurrence.

ICMSF (1988) defines "hazard" as the unacceptable contamination, growth or survival of bacteria in food that may affect food safety or quality (spoilage) or the unacceptable production or persistence in foods of substances such as toxins, enzymes or products of microbial metabolism. The U.S. National Advisory Committee on Microbiological Criteria for Foods (NACMCF, 1992) defines a hazard as a biological, chemical or physical property that may cause a food to be unsafe for consumption (NACMCF, 1992); for more details see Section 2.2.1.

Identification of hazard information from developed countries may not always be relevant to the situation in the developing country such as Oman. Specific hazards in developed countries are normally identified through epidemiological studies, collation of consumer complaints, product alerts etc. Such information is often not collected in developing countries, as there is no central authority accumulating and publishing information on reported outbreaks of foodborne illnesses etc. In Oman, food processing industries have difficulty obtaining the scientific information necessary for developing sound hazard assessments, or for identifying the specific support needed to implement HACCP. Databases on foodborne disease outbreaks, national food poisoning statistics, biological hazards and other reference materials are not readily available, or are non-existent. Such information is not collated in Oman, as there is no central authority collecting and publishing information on reported outbreaks of foodborne illnesses, a gap which needs to be filled (see Chapters Five, Eight and Nine).

Principle 2: Determine critical control points (CCPs)

After the hazards have been identified, then procedures should be established for their control. The definition of a critical control point (CCP) is of practical importance, because it defines the limits of what can be achieved by a HACCP programme.

Since the introduction of HACCP, the definition for a CCP has changed. As originally stated, "the critical control point is a concept adopted by the panel to describe the location(s) or point(s) in a food processing operation at which failure to prevent contamination can be detected by laboratory tests with maximum assurance and efficiency" (APHA, 1972). This narrow definition focused upon preventing contamination, such as from *salmonellae*, and the use of laboratory tests to detect failures if they occur. This original definition for CCP was modified by ICMSF in 1980 to "a location or a process which, if not correctly controlled, could lead to contamination with unacceptable growth" (WHO, 1982).

Then ICMSF defines a critical control point as "a location, practice, procedure or process at which control can be exercised over one or more factors which, if controlled, could minimize or prevent a hazard" (ICMSF, 1988). The definition is realistic in its recognition that there are degrees in the ability to control a hazard. This led ICMSF to propose two general classifications of CCP based upon the level of confidence that hazards can be controlled, CCP1 and CCP2. A CCPl will assure control while a CCP2 will minimize but cannot assure the control of a hazard. The net result of the effort applied to controlling a CCPl should be a high level of confidence that the hazard has been prevented. In the case of a CCP2, the risk of the hazard can be minimized, but elimination of the hazard cannot be assured (ICMSF, 1988). At a CCP2 the risk of the hazard can be significantly higher if no attempt is made to control the hazard.

According to the definition currently accepted by the US (NACMCF, 1992) a CCP is a point, step or procedure at which control can be applied and a food safety hazard can be prevented, eliminated or reduced to an acceptable level. (Note: no distinction is made between CCPl and CCP2). Thus, for every step, location or procedure identified as a CCP, a detailed description of the preventive measures to be taken at that point should be provided. If there are no preventive measures to be taken at a certain point, it is not a CCP. Thus CCPs should be carefully chosen on the basis of the risk and severity of the hazard to be controlled and the control points should be truly critical (FAO, 1994a). In any operation, many control points (CP) could be necessary but not critical due to low risk or low severity of the hazard involved. Some of these control points are there as a result of company rules for good manufacturing practice, product reputation, company policy or aesthetics. The distinction between Control Points and Critical Control Points is one of the distinctive features of the HACCP concept, which sets priorities on risks and emphasizes operations that offer the greatest potential for control.

WHO (1992) argues that the selection of critical control points depends on (a) the likely hazards, their estimated severity and risk in relation to what constitutes unacceptable contamination of food, or survival or growth of microorganisms; (b) the operations to which the product is subjected during processing and preparation; and (c) the subsequent use of the product.

The determination of a CCP in the HACCP system can be facilitated by the application of a decision tree, introduced by Codex in 1993, which implies a logical reasoning approach (Fig. 2.2). The application of the decision tree should be flexible according to the type of operation (production, slaughter, processing storage, distribution or other). It consists of a systematic series of organised questions to help in decision making. It is designed to assess objectively whether a CCP is required to control the identified hazard at a specific operation of the process. For developing countries the methodology is very useful.

Commission Decision 94/356/EC defines critical points as "any point, step or procedure at which control can be applied and a food safety hazard can be prevented, eliminated or reduced to acceptable levels" (Article 2). It goes on to require that all critical points which ensure compliance with Directive 91/493/EEC be identified, and employs an Annex to make detailed recommendations on how that should be done.

Identification of CCPs is a crucial step in developing and maintaining the HACCP system, and is a part of the HACCP system. It requires technical expertise and a quantitative approach. A common problem in identifying a CCP is that too few will obviously give inadequate quality assurance, and too many will dilute the effort and increase the cost, and it also suggests a lack of qualified experts. In Oman, food processing industries have difficulty obtaining the scientific information necessary for developing sound hazard assessments, or for identifying specific support needed to implement HACCP. Lack of technical references and epidemiological data results in inability to distinguish between the relative risks of different pathogens for particular foods.

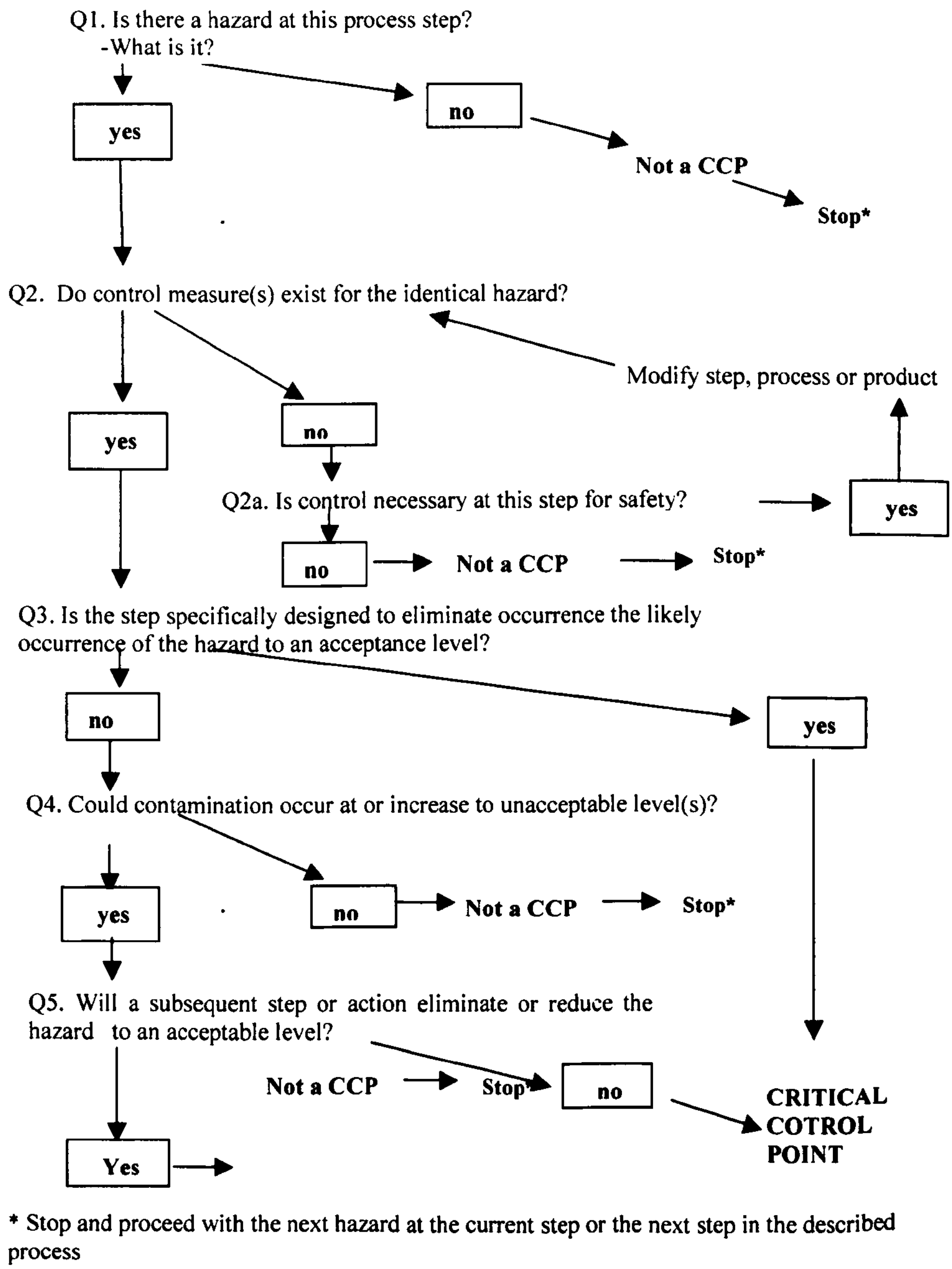


Figure 2.2 A CCP decision tree (adapted from Codex, 1997a).

Principle 3: Establish critical limits for each CCP

At each CCP critical limits are established and specified. Critical limits are defined as criteria that separate acceptability from unacceptability (FAO, 1998, Commission, 1994). A critical limit represents the boundaries that are used to judge whether an operation is producing safe products (MFSCNFPA, 1992). A CCP may have more than one critical limit. If any of the critical limits is violated, then the CCP is out of control and the potential for an unacceptable health hazard exists (Buchanan, 1995). Examples of critical limits include minimum processing time and temperature, maximum refrigeration holding temperature, minimum hot holding temperature, maximum pesticide application level, maximum screen size on sifter, maximum pH, maximum fill weight, maximum viscosity. Other examples can be seen in Table 2.5.

FAO (1998) recommends that the critical limits should meet the requirements of government regulations and/or company standards, as well as being supported by other scientific data. In some cases, food control regulatory authorities provide information on which to establish critical limits based on known food hazards and the results of risk analysis (e.g. the time/temperature requirements for thermal processes such as pasteurisation, cooking, retorting; maximum number and size of physical contaminants, chemical residues).

It is essential that those responsible for establishing critical limits have knowledge of the process and of the legal and commercial standards required for the product. Sources of information on critical limits may be based on scientific publications or research data, regulatory requirements and guidelines, experts (e.g. thermal process authorities, consultants, food scientists, microbiologists, equipment manufacturers, sanitarians, academics) and/or experimental studies such as in-house experiments, and contract laboratory studies. When critical limits are not available from external sources the Commission recommends that the responsible team should validate the chosen variables. Finally, the critical limits for each CCP should be documented and information on how each of the critical limits is derived should be kept as part of the formal HACCP plan.

Table 2.5. Examples of critical limits

Hazard	CCP	Critical limit
Bacterial pathogens (non-sporulating)	Pasteurisation	72°C for at least 15 seconds
Metal fragments	Metal detector	Metal fragments larger than 0.5mm
Bacterial pathogens	Drying oven	Aw < 0.85 for controlling growth in dried food products
Excessive nitrite	Curing room/brining	Maximum 200 ppm sodium nitrite in finished product
Bacterial pathogens	Acidification step	Maximum pH of 4.6 to control *Clostridium botulinum* in acidified food
Food allergens	Labelling	Label that is legible and contains a listing of correct ingredients
Histamine	Receiving	Maximum of 25 ppm histamine levels in evaluation of tuna for histamine[a]

Source: FAO, 1998

[a] Regulatory action level is 50 ppm, but histamine levels may increase during processing. Therefore industry may want to set lower histamine critical limits at receiving.

An issue for developing countries, including Oman, is access to relevant background information on what the real hazards are for their particular products and processes. Obtaining information to determine the appropriate critical limits can be difficult (i.e., time and temperature controls for lethal heat treatments, intrinsic product controls such as pH, *aw*, preservative levels etc.). Examples include maximum permissible levels of pesticides and additives. As many of the products produced in developed countries are unique to the country concerned, there may be no international or importing country standards that have been determined. Moreover, the limits desirable for developed and developing countries may differ and it is not always economically feasible to set the limit at the lowest common denominator.

Principle 4: Establish monitoring procedures

Monitoring is a planned sequence of observations or measurements to assess whether a CCP is under control, and to produce an accurate record for future use in verification (NACMCF, 1992). The monitoring programme "should describe the methods, the frequency of observations or measurements and the recording procedure. Observations or measurements must be able to detect loss of control at critical points and provide information in time for corrective action to be taken" (Chapter II.2 Annex to Decision 94/356/EC).

In general the survey of Omani factories suggested inadequate monitoring procedures. Monitoring serves three main purposes. First, monitoring is important in that it tracks the system's operation. If monitoring indicates that there is a trend towards loss of control, for example exceeding a target level, then action can be taken to bring the process back into control before a deviation occurs. Second, monitoring is used to determine when there is loss of control and a deviation occurs at a CCP, i.e., exceeding the critical limit. Third, it provides written documentation for use in verification of the HACCP plan (NACMCF, 1992; Codex, 1997a; NACMCF, 1998).

Moreover, the monitoring of CCPs requires a combination of rapid procedures (e.g., visual observations, time, temperature and pH measurements and moisture regulation), since these are applied on-line, rather than at the end of the process (Codex, 1997a). Detailed microbiological testing in laboratories away from the process is not always helpful because of time constraints, but may be used to establish the safety of imported foods, and products which have microbiologically sensitive ingredients.

There are five main types of monitoring (IAMFES, 1991; ICMSF, 1988). These are:

- visual observation (i.e., visual examination of raw materials, cleanliness of plant and equipment, worker hygiene, processing procedures, storage and transportation);
- sensory evaluation (monitoring product attributes such as flavour and odour which can sometimes provide a quick indication of loss of control);
- physical measurements (tests of temperature, pH, total acidity, salt, *aw* and humidity);
- chemical testing and
- microbial examination (in certain foods, processes, ingredients, or imports. There may be no alternative to microbial testing) (NACMCF, 1998).

Garrett and Hudak-Roos (1990) suggest ten simple guidelines to follow when establishing a monitoring system:

- asking the right questions;
- appropriate data analysis;
- the location of data collection;
- absence of bias;
- understanding the needs of the data collector, including training, and experience;

- designing simple but effective data collection forms;
- clear instructions to monitors;
- testing of the system;
- training;
- auditing of the collection process.

Assignment of the responsibility for monitoring is an important consideration for each CCP. Specific assignments will depend on the number of CCPs, the preventive measures, and the complexity of monitoring (NACMCF, 1992). Such individuals are often associated with production (e.g., line supervisors, selected line workers and maintenance personnel) and, as required, quality control personnel.

Principle 5: Establish corrective action

Deviation implies a failure to meet critical limits (Codex, 1997a, Commission 1994). Procedures need to be in place to identify, isolate and evaluate products when critical limits are exceeded. Control procedures to cater for deviations are suggested by FAO (1998) and Tompkin (1992). Corrective action aims to bring the process back into control (i.e., correct the deviation). All products produced while the CCP was "out-of-control" should be placed on hold (NACMCF, 1998).

Principle 6: Establish verification procedures

Verification is defined by NACMCF (1998) as those activities, other than monitoring, that determine the accuracy of the HACCP plan, and that the system is operating according to the plan. Verification is a crucial step during development and continuous maintenance of the HACCP plan and when a control system based on HACCP is first introduced for a new process. Qualified people who are capable of detecting deficiencies in the plan or its implementation should undertake verification.

When a HACCP plan is being developed, initial verification is necessary to determine that the plan is scientifically and technically sound, to ensure that all hazards and CCPs are identified, and control measures are properly implemented.

Unbiased independent authorities usually conduct verification. It can be done by internal audits or by outside parties (regulatory agencies, third party experts). Both manufacturers and the regulatory agencies have roles in verifying HACCP systems (ICMSF, 1991, NACMCF, 1998). According to Bryan et al. (1993), as a primary function of regulatory agencies, verification should include:

- evaluation of each element of the HACCP plan;
- on-site review of all flow diagrams and appropriate records;
- reviewing deviations and product disposals, and
- confirmation that CCPs are kept under control.

For the Commission verification procedures may include: "inspection of operations, validation of critical limits, review of deviations, corrective action and measures taken with regard to the product, audits of the own-check system and its records" (Chapter III Annex to Decision 94/356/EC).

In addition to the periodic verification of an established HACCP system, subsequent verification procedures are necessary when there is an unexplained system failure; a significant product, process, or packaging change occurs; or new hazards are recognised. Mortimore and Wallace (1994) described some of the activities that should be considered when verifying and maintaining the HACCP system. These are:

- ongoing verification through audit, to determine whether activities and results comply with the documented procedures and also whether these procedures are implemented effectively and are suitable to achieve the objectives;
- analysis of data, periodic reviewing of HACCP records;
- keeping abreast of emerging hazards. Knowing the hazards and their weaknesses, in-depth, is the way to effectively apply control measures;
- updating and modifying HACCP plans. The HACCP plan should be modified to satisfy the introduction, or replacement, of systems and operations;
- ongoing training requirements. Changes in the personnel, process or plant should be accompanied with training activities.

Tompkin (1994) developed a general questionnaire that can be used during verification of HACCP plans by regulatory authorities and quality-control (internal or external audits) staff. This is included in Appendix V.

The results of all verification procedures should be documented. The report should include the verification of a functioning HACCP plan intact and fully completed records and documents associated with CCPs records verifying proper calibration and operation of all monitoring equipment and proper handling and documentation of deviation.

Principle 7: Establish record-keeping and documentation procedures

HACCP Principle 7 requires that effective record-keeping procedures be established to document the HACCP system. A record shows the process history, the monitoring, the deviations and the corrective actions that occurred at the identified CCP. FAO (1998) list the types of records that have to be kept as a part of the HACCP system. There is little evidence that the record keeping procedures in Omani factories are as rigorous as they should be.

Records should be kept of all areas which are critical to product safety, as written evidence that the HACCP Plan is being followed. This may also support a defence under litigation proceedings. Records will also be useful in providing a basis for analysis of trends (which in turn may contribute towards improvements in the system) as well as for internal investigation of any food safety incident that may occur. Mortimore and Wallace (1998) discuss the length of time for which records should be kept. Good record keeping is also a legal requirement in Directive 91/493/EEC (e.g. Article 6).

C. Post-HACCP

HACCP is a management tool which focuses attention on food safety (NFPA, 1993). Thus, as for other tools present in the processing environment, HACCP must be maintained. An important aspect of maintaining the HACCP system is to ensure that all individuals involved are properly trained so they understand their role and can effectively fulfil their responsibilities. It should be closely monitored and checked upon, and also, in due course of time, old parts should be replaced with new ones. To ensure that the HACCP plan is implemented and operates effectively, a number of techniques are recommended by Khandke and Mayes (1998). These techniques are:

- listening to the views of the personnel responsible for implementation;
- verification procedures;
- regular reviewing of record keeping and documentation activities;
- establishing a system that takes account of changes of processing that might occur daily/weekly/monthly;
- establishing internal and external auditing of the HACCP plan;
- a review of critical limits arising from new developments e.g. changes in legislation, new scientific data on infectious dosage, emerging hazards, new areas of risk, changes in consumer profiles, changes in product usage etc.

Therefore, HACCP is not an end itself; instead, it is clear statement by companies that there exists a preventive approach to produce food.

2.5. Practical Implementation of HACCP

Successful implementation of HACCP in the food industry depends on close cooperation of regulatory agencies and their respective industries. In this section, the roles of both regulatory agencies and industries are summarised, together with the pathway to implement HACCP successfully. However, there are some barriers in the implementation process which may impede the use of HACCP system in the food industry.

2.5.1. Reasons behind implementing HACCP system

Mortimore and Wallace (1998) review some of the reasons for using HACCP in food processing plants. According to the authors these are:

Management of product safety

HACCP is a system of food control based on prevention. In identifying where the hazards are likely to occur in the process, HACCP puts in place the measures needed to prevent those hazards occurring. This will facilitate the move towards a preventive quality assurance approach within food business, reducing the traditional reliance on end-product inspection and testing. All types of food safety hazards, biological, chemical and physical are considered as part of the HACCP system, so management of food safety is asserted.

Limitations of inspection and testing

End-product testing is reactive. Detection of a pathogen or high bacterial counts involves remedial action by operators or regulatory authorities but does not prevent the hazard happening again. Microbiological testing is also time consuming. In most cases, the food in question is consumed before the test results are known. Except for the recent advances in the development of rapid techniques detection of most organisms, it may take several days, and, at times, periods longer than the shelf-life of many perishable foods.

It is usually impossible to achieve a sampling frequency that is adequate for reliable detection of low levels of pathogens given the larger number of samples needed (NACMCF, 1992). This is especially so in developing countries such as Oman. Thus, reliance on end-product testing for food safety control can lead to false confidence about the safety of a process. Again, microbiological testing is often not accessible to those sectors which have been shown to account for most outbreaks of foodborne diseases food service establishments and homes (Wall et al., 1995).

External pressures

As HACCP becomes a regulatory requirement, this will be the main driver for its implementation. This is certainly the case in Oman. There are other pressures, such as government, customers, enforcement authorities, media and international standardisation. In Europe, one of the most powerful drivers is the European Union, for example, Council Directive No. 93/43/EECon the hygiene of foodstuffs requires food business operators to apply HACCP. In the UK the statutory defence of Due Diligence contained within the Food Safety Act (1990) has forced producers to developed HACCP.

Prioritisation of improvement

Because HACCP consists of the analysis of the production process, it can also detect weak areas which require attention. In that respect, HACCP places into proper perspective the factors that are of the highest priority and must be controlled (Tompkin, 1994).

2.5.2. Roles of the regulatory agencies and industry

The role of regulatory agencies is to ensure the appropriate application of HACCP activities by the various food sectors and to facilitate HACCP implementation. In most countries, including Oman, regulatory authorities are statutory bodies and have a responsibility to provide leadership in food safety control by accepting and promoting HACCP principles for the food processing and manufacturing industry. For a summary of the role of the competent authority in Europe, see Appendix IX of this thesis, and Chapter V of Annex to Council Directive 91/493/EEC.

While the production of safe food products is primarily the responsibility of industry, the regulatory authorities have responsibilities both as enforcers and as facilitators. As enforcers, they check the appropriate implementation of HACCP plans and confirm that they are properly designed and effectively implemented. As facilitators, they advise and assist the industry in developing HACCP plans and in implementing appropriate food safety controls. In Oman, for example, regulatory authorities may develop or facilitate the writing of model HACCP plans for various food products or operations. They may also provide HACCP training for the industry and collaborate in the development of individual HACCP systems.

WHO (1993) recommends the following roles for the regulatory authorities:

- establishment of national programmes to ensure the quality, scientific validity and consistent application of HACCP systems by working with interested groups to identify food safety hazards and the development of strategies for their control. Epidemiological and scientific data gleaned from world wide sources can be used to identify hazards and conduct risk assessments to provide information which can be used to improve HACCP plans;
- provision of technical support for the design and application of HACCP plans. This may be done by demonstrating how the principles and goals of HACCP should be applied;
- regulatory verification and audit, including access to industry records to verify the HACCP plans, which according to Bryan et al., (1993) includes:
    - pointing out hazards within operations during visits to establishments;
    - modifying hazardous processes when detected during hazard analysis or verification activities to make operations safer or prohibiting the operation;
    - advising on effective monitoring procedures;
    - approving HACCP plans.
- regulatory response to inadequate HACCP plans and inadequate application by investigating the cause for failure of a HACCP plan or existing regulation so that changes can be made to prevent the re-occurrence of a food safety hazard;

- regulatory guidelines for appropriateness and severity of corrective action, e.g. with reference to microbiological criteria;
- regulatory response to failure to take corrective action;
- encouragement of and participation in training programmes to promote the use of HACCP and training and educating personnel in the food industry and in the health agencies in local authorities (Bryan et al., 1993).
- regulatory sanctions which may apply if an industrial sector does not take up HACCP in a voluntary environment, e.g. increased frequency of inspection and increased requirements for traditional process control and
- utilization of third parties in development, validation and audit of HACCP systems.

To clarify the relationship between HACCP, microbial criteria and risk assessment regulatory agencies may have to become involved in some new roles, as summarised by Buchanan (1995):

- assessment of the current technological status of the industry for its ability to control pathogens as new information emerges;
- identification of areas where additional technologies are needed;
- fostering the acquisition and dissemination of epidemiological, public health, and microbiological data on:
- incidence of foodborne disease;
- factors that contribute to the incidence of outbreaks and sporadic cases; and
- microbiological profiles and characterisations of major food products and processes that will be essential to conduct meaningful hazard analysis.
- developing techniques in microbiological risk assessment;

- evaluating the performance of HACCP for assessing "equivalence" for products in international trade.

Similarly, NACMCF (1994) identifies the roles of the food industry in developing, implementing, and maintaining an effective HACCP system. It recommends that each facility should form a HACCP team that is responsible for the HACCP plan. The facility should maintain an accurate, up-to-date HACCP plan which can be reviewed by regulatory personnel. Amendments to the HACCP plan will be made when the plan has been found to be inadequate. The industry should promote the use of HACCP and should exercise whatever action is deemed necessary to prevent unsafe food from reaching the consumers.

2.5.3. Barriers in implementing HACCP

A number of barriers impede the implementation of HACCP in Oman and probably in many other developing countries. Potential barriers to the implementation of HACCP need to be identified and examined as an initial step in the development of any HACCP implementation strategy. These barriers vary from country to country or from sector to sector. Some may be due to internal factors in individual businesses, e.g. the level of knowledge or resources available to a business. Others may be due to external factors, such as the availability of government or industry support.

In the absence of a legal pressure, as is the case in Oman, voluntary adoption of HACCP is inconceivable without a full understanding of the system, the procedures to implement it, and the benefits of its application. In the following paragraphs, an account of factors likely to hinder wider acceptance and practical implementation of HACCP in food businesses is presented.

Barriers related to limited understanding of the HACCP system

It is important that available information on the principles and application of HACCP is effectively communicated. Information about HACCP is mainly targeted at experts, academics and regulatory bodies, while some managers in the food industry (especially small businesses) appear to remain unaware of the system. For instance, a study conducted to evaluate HACCP implementation in Scotland, reported that over half of the food operators sampled were not aware of the strategy (Ehiri and Morris, 1995). The study reveals that most managers in the food industry have limited understanding of the principles and application of the HACCP system.

Barriers related to time and cost constraints

Time constraints and resource requirements of HACCP implementation have been cited as crucial factors influencing acceptance and implementation of the system by food operators (Gormley, 1995; Summer and Albrecht, 1995). There is limited information on the constraints of economic factors on HACCP implementation. In a study of attitudes and opinions of food operators regarding HACCP implementation in the USA (Karr et al., 1994), over 4000 of the respondents stressed that the regulatory authorities had not presented convincing enough evidence of research to justify HACCP and, in particular, information on the costs of the system (as opposed to its impact on food safety). The three major economic concerns highlighted by the respondents were: (a) high cost of laboratory facilities; (b) high cost of training employees; and (c) high cost of operating the system. It is, however, questionable, whether economic constraints are the principal obstacle to HACCP implementation in Oman (see Chapter 8).

Barriers related to prerequisite programmes

Where the HACCP plan has been developed to cover only significant food safety hazards but no formal prerequisite programmes are in place as support, the major food safety issues should be covered but the overall system is weakened by lack of support, according to Wallace and Williams (2001). It is also possible that a company might develop prerequisite programmes and HACCP, and yet fail to link the systems together.

Barriers related to education and training

Tompkin (1990), WHO (1993), Ehiri and Morris (1994) and Mortimore and Wallace (2001) discuss how weakness in human capital constrains HACCP implementation. HACCP is carried out by people. If the people are not properly experienced and trained then the resulting HACCP system is likely to be ineffective and unsound. Employees should understand what to do to assure food safety, and should also understand why they are performing a particular task (Tompkin, 1990). Management needs to be committed to investing in educating and training employees to build awareness and a positive, proactive attitude toward food safety. In addition, management should encourage and recognize employee feedback, even though the HACCP plan may have been created by an expert in food safety. In Oman, where most seafood processing plants consist of small size companies (in terms of number of employees and turnover) and there is a lack of technically trained employees, the training requirement could be a potential problem for this segment of the industry. It is doubtful if any company can implement HACCP without specific training. This is particularly true for the small company with limited access to information and often without the time or skills to interpret textbooks.

Barriers related to the HACCP system

HACCP plan: The HACCP plan has to be plant friendly. HACCP plans that are too complicated and burdensome are likely to fail. This can occur when technical people alone design a HACCP plan (Pierson and Corlett, 1992).

HACCP team: HACCP teams should include individuals from different disciplines, who are familiar with the process. This may present problems in Oman, as medium and small businesses may not have people with the appropriate skills and may lack the financial resources to use external specialists. If that broad expertise is not available, external expertise have to be sought (NACMCF, 1998; NFPA, 1993). However, NACMCF (1998) states that a HACCP plan that is developed by outside sources may be erroneous, incomplete, and lacking in support at the local level. Furthermore, Tompkin (1990) argues that the "expert" can be a weak link in the system. The fact that several experts often provide different opinions raises questions of credibility and confidence in the overall system. In addition external consultants are usually expensive and some businesses cannot afford them. This supports the case for collaborative efforts to provide smaller businesses with adequate tools to develop HACCP.

There are a number of additional pitfalls for developing countries, including Oman, which are little discussed in the literature but which have been identified in the current study.

Conducting a hazard analysis: As noted above, both identification and evaluation of hazards requires knowledge of which micro-organisms are potentially of significance in the food being produced, bearing in mind the nature of the process and the subsequent history of the food. The process requires significant expertise in the collection and analysis of known data and the competence to determine likely outcomes, which may be lacking in developing countries, Codex has advocated that the HACCP team apply best judgement to determine the significant hazards (Codex, 1997b). This requires access to background information which may not be known in developing countries which have differing pathogens, physical and chemical hazards from developed countries from which the majority of available literature on agricultural practices and possible hazards has been written.

In the process of identifying hazards, the crucial issue is access to relevant background information on what the real hazards are for a particular product and process. In Oman, food processing industries have difficulty obtaining the scientific information necessary for developing sound hazard assessments, or for identifying specific support needed to implement HACCP. Databases on foodborne disease outbreaks, national food poisoning statistics, biological hazards and other reference materials are not readily available, or are non-existent. Such information is often not collated in Oman, as there is no central authority collecting and publishing information on reported outbreaks of foodborne illnesses etc.

Determining CCPs: The identification of CCPs, as a part of the HACCP system, requires technical expertise and a wide knowledge in the product and processing (Bryan, 1990). There have been several definitions and interpretations of CCPs, both from academia and from other institutions, which may have introduced some degree of doubt on which definition to follow. A common problem in identifying CCP is that too few will obviously give inadequate quality assurance, and too many will dilute the effort and increase the cost, which indicates the lack of qualified experts. CCP determination relies on proper hazard analysis. Therefore, failing to justify hazards means failure in determining CCP.

Establishing critical limits: Obtaining information to determine the appropriate critical limits can prove to be difficult in Oman as this is largely a scientific process that requires reference to known and scientifically determined values. Examples include time and temperature controls for lethal heat treatments, intrinsic product controls such as pH, *aw*, preservative levels. The limits set for importing countries may differ and, as such, it is not always economically feasible to set the limit at the lowest common denominator. As many of the products produced in developing countries are unique to that country, it may be that no international or importing country standards have been determined.

Monitoring procedures: The importance of monitoring cannot be underestimated and it is crucial that the person undertaking the monitoring of the CCP has an understanding of the importance of the task and in doing so will record the true results (Christian, 1994;

FAO, 1998). Monitoring is one of the most labour intensive, and therefore expensive, activities undertaken by a food company. It therefore makes sense that monitoring needs to be accurate and provide a true indication of the results. Inaccurate and false results are often recorded by employees, due to the mistaken belief that they will be punished if the results are not what they should be, and that the company wants to see records that indicate control of process, whether or not this is the case. There may be insufficient facilities to monitor a HACCP programme and access to testing facilities and the expense of microbiological and chemical testing can be prohibitive in developing countries. Although the process may be more labour intensive than that utilised in developed countries, visual inspection is not always able to detect some contaminations.

Establish corrective actions: There is a need to take corrective action because a critical limit that has not been met will often mean production losses and consequently authority for these decisions is often delegated to senior management (Bryan, 1990; Codex, 1993). This is not always appropriate, as a senior manager may not have the technical expertise to make these decisions and may not always be available to make urgent decisions. The HACCP team should carefully consider who has the appropriate skills and knowledge to determine corrective actions. Corrective action needs to be predetermined in the plan. Where data are not available on the safety of reworking product, challenge testing may be required by the organisation. This requires access to the appropriate laboratory facilities.

Verification: To be effective, the HACCP plan requires verification to prove that the HACCP plan is capable of producing safe food. Appropriate emphasis needs to be given to verification as without internal verification, the HACCP plan may not continue to produce safe food and the team will not know when changes need to be made or what changes are required (Mortimore and Wallace, 1998). Verification is very important for exporting companies as it provides the proof that there is a HACCP system in place and that the system has been implemented and is effective in the production of safe food (Caswell and Hooker, 1996). Verification of the HACCP plan and implementation is one of the problems that hinder the successes of the system because few people are trained in this field.

Documentation and record keeping: When documenting the HACCP system, it should be written in the language that is understood by the people actually following the plan. There should be instructions in writing on how to monitor a CCP if the person on line doing monitoring is not literate, as is the case in many developing countries. There may be some countries that require HACCP to be documented in English for their own verification purposes, or to fulfil exporters' needs but, wherever possible, the plan should be in the local language, and obviously monitoring records will also be completed in the local language. One final note on the documentation of a HACCP system is that procedures do not need to be lengthy.

2.5.4. Pathway to successfully implement HACCP

The regulatory authorities and academia have a role to play in the successful implementation of HACCP. There is a need for government and industry to work in collaboration to provide the food industry with appropriate epidemiological and scientific data to help in identifying hazards, conducting risk analysis and improving HACCP plans. The success of a HACCP system depends on educating and training management and employees in the importance of their role in producing safe foods. Thus, there is a need to prepare appropriate information and training materials to train personnel from both industries and regulatory/enforcement authorities in HACCP techniques. Maintaining an effective HACCP system depends largely on regularly scheduled verification activities. The HACCP plan should be updated and revised as needed.

2.6. Food safety strategies

Food safety control represents conditions and measures that are necessary during the production, processing, distribution and preparation of food, to ensure that when consumed, it does not constitute a risk to health (Miyagishima et al., 1995). Therefore, governments are increasingly expected to ensure the nation's health, through the development of mechanisms of food protection such as research, technical advice, legislation, surveillance, inspection, enforcement, monitoring, and education through the community; in other words, to develop a strategy for food safety.

Since the safety of foods has become a matter of public concern, government and industry share a common goal to ensure the safety of food. The government has the responsibility for establishing the standards, legislation and enforcement programmes necessary to control food quality and safety (external mechanisms). Industry has a responsibility for implementing quality assurance systems (e.g. HACCP) where necessary to ensure compliance with the standards laid down and legislation (internal mechanisms). A helpful division of food protection mechanisms can be established between those controls and practices developed by the food industry, and those which usually are the responsibility of other organisations than the food industry itself, such as government.

What then are the main components of a food safety strategy? Some ideas, gleaned from the literature, are summarised in the next section.

2.6.1. Internal mechanisms

Managers of food-processing business are responsible for the processing of wholesome and safe food products for human consumption (Meaning, 1988; Baird-Parker, 1994; Sprenger, 1995). They should have a clear understanding of biological, chemical and physical hazards which may be of significance throughout the process line. According to the nature of the hazard, they should then consider adequate preventive measures to reduce risks to a minimum. The main strategic areas of concern are those which represent a source of contamination to the final product. These areas are personnel, food and environment.

A. Personnel

Persons who harvest, slaughter, store, transport, process or prepare foods are often responsible for the microbiological contamination of these foods. Food handlers who are infected or colonized by pathogens may contaminate foods by touching them. Any food handler may transfer pathogens from raw foods (e.g. meat, poultry, fish) to foods that will not be heated subsequently to ensure safety. Poorly controlled processing (e.g. inadequate heating or refrigeration) may increase the hazard by permitting survival or multiplication of pathogens or spoilage organisms. Epidemiological data have shown that in 5% of the outbreaks reported in England and Wales, 10% in New South Wales, Australia, and 20% in the United States, food handlers directly contaminated foods (Roberts, 1982; Davey, 1985; Bryan, 1978). The diversity in percentages is probably explained by differences in reporting levels, rather than by underlying causes.

A number of strategies for detecting infected food workers and to preventing them from handling foods have been summarised by ICMSF (1988). These are

Pre-employment and periodic medical or laboratory examination

In some countries, codes of public health practice (Ali et al., 1992; Bryan, 1985) require that food workers have pre-employment or periodic medical examinations. These may include physical examinations and certification to medical histories, testing of blood specimens for evidence of venereal disease, X-ray examinations for evidence of tuberculosis and examination of stools for parasites, *Salmonella, Shigella,* or other microorganisms. The position set out in Chapter III of the Annex to Council Directive 91/493/EEC is that employees in fish processing establishments should provide a medical certificate guaranteeing no impediment to employment on health grounds. This requirement is generalised in Council Directive 93/43/EEC which proposes medical examination before recruitment and a further medical examination for clinical or epidemiological reasons.

Examinations of workers during investigations of foodborne illness

Physical examinations of workers and/or collection of specimens may be essential during investigations of outbreaks of foodborne illness. In outbreaks of *staphylococcal* food poisoning, phage-typing cultures from workers' noses and skin lesions can help to identify the source of contamination. In outbreaks of salmonellosis, shigellosis and *Escherichia coli* diarrhoea, stool or rectal-swab specimens from food handlers can sometimes lead to the source of contamination. Serotyping, phage-typing or some other means of comparing epidemiological markers needs to be carried out on isolates to find out the source.

Examinations by, or reporting illness to, management

Supervisors of food establishments may be required to inspect the hands and faces of personnel for skin lesions and exclude those with lesions from handling cooked foods and from other critical handling operations, and workers should be required to report all illnesses. Supervisors should then decide, with medical consultation if necessary, whether to suspend such persons until the condition has cleared up, to advise them to seek treatment or to arrange for a change of tasks not requiring contact with food. These actions have to be taken even in the absence of positive microbiological findings. If the decision is made to allow the person to continue to work, reinforced instruction in personal hygiene and food handling should be given. ICMSF (1988) also suggests that inspectors during verification of HACCP should become more observant of food workers who have skin lesions or jaundice, or who otherwise appear ill. Oman has a procedure requiring the Ministry of Health to conduct medical examination of food handlers before recruitment.

B. Food

Ensuring the highest microbiological quality of raw products, temperature control, storage and stock rotation, suitable packaging and adequate distribution and service help to ensure the safety of the product. Therefore, designing food to be microbiologically safe is an important technological challenge facing the modern food industry. Buchanan and Deroever (1993) have defined the process as "microbial profiling", while Leistner

(1992) calls it "hurdle technology". Both definitions refer to processes by which relevant characteristics of a food are matched against the requirements of foodborne pathogens to secure microbial stability. There are two strategic goals in the microbial profiling of foods: (a) identifying the pathogens that are likely to be a problem in a food and (b) identifying potential factors that can be manipulated to control the organisms.

C. Premises and equipment

Product protection starts with the correct planning, design, and construction of the processing plant in accordance with the operation that will be taking place. The environment surrounding the product is also important, since it may put harmful environmental agents in contact with food.

Hygienic design of food handling areas is included in the food regulations in most industrialized countries as well as in Council Directives 91/493/EEC and 93/43/EEC. Internationally this is covered in the Codes of Hygienic Practice of the FAO/WHO Codex Alimentarius Commission (Codex, 1993).

2.6.2. External mechanisms

External food controls include all those measures usually exercised by regulatory authorities. These measures act as the safeguards of public health at a national level. The maintenance of food safety depends on research which provides a continuous understanding of food safety; the advice of expert advisory committees, surveillance to monitor food composition and its safety, and enforcement which enable the government and the local authorities to ensure that statutory provisions are met. The final link in the maintenance of food safety is the promotion of education at every stage in the food production, import and distribution.

A. Expert advice

The significance and effectiveness of food safety controls depends on appropriate medical, scientific and technical advice. This might come from various institutions/committees (e.g., advisory committees on pesticides, veterinary product committees and committees on the microbiology of food) to enable decision-makers to base their decisions on objective evidence. Some of the committees might have statutory roles under specific legislation. Others may be formed, *ad hoc*, when new developments or problems create the need of additional expertise.

B. Research

Industry, government, and academia generally have defined roles in food safety research. Universities and government research agencies typically study new technologies and/or methodologies for improving up the safety of food supply. As these are developed, industry, in collaboration with academia, tests and verifies the effectiveness (including costs) of these new technologies and methods.

The UK Government spends over £8 million a year on research in order to update current knowledge and provide a scientific and technical assessment of new technologies. Research studies help to set the standards by which food is produced. Research is being carried out in the government laboratories of the and by institutes such as the Institute of Food Research. Other organisations such as the Public Health Laboratory Service make a major contribution to research, based upon its routine work.

It is a policy of British government that the Food Standards Agency takes over all Government's expenditure on research and surveillance in the areas of food safety, nutrition and consumer protection (MAFF, 1998). Furthermore, the Agency claims to base its policies and decisions on the best possible science, achieved through openness, peer review and, where possible, by competition between research providers. In order to access the best available science, the agency maintains the plurality of science funding, retains close co-ordination between all funders of research in the food area and has taken over responsibility for most of the wide range of surveillance work undertaken by the Health and Agriculture Departments. In this thesis, it is proposed that Sultan Qaboos University should take the initiative in research and deliver advice to the regulatory authority in food safety in Oman.

C. Surveillance of foodborne disease

Surveillance of foodborne disease is an epidemiological activity and a rational approach for the identification and control of foodborne diseases in the human population (Bryan, 1986). Surveillance of foodborne disease is an important component of food safety programmes at all levels of government and within each type of food industry (CAST, 1994; Guzewich et al., 1997; Todd et al., 1997). It relies on systematic collection of data on foodborne diseases, including their contributing agents and factors which contribute to their distribution and spread. Surveillance of foodborne disease consists of (a) receiving notification of illness, (b) investigating incidents and reporting findings, (c) collating and interpreting data, and (d) disseminating information to those who are empowered to take appropriate action (Guzewich et al., 1997; Wall et al., 1996). Surveillance has traditionally served three purposes: (a) disease prevention and control, (b) knowledge of disease causation and (c) administrative guidance for preventing the diseases in the future (Bean et al., 1997).

In developing countries, the contribution of inadequate basic infrastructures to the problem of foodborne diseases has been documented (Akoh, 1989; FAO/WHO, 1989a; Baptist, 1989). The main constraints that those countries are facing is the rising burden of finding the resources needed to maintain facilities such as buildings, laboratory equipment and vehicles, as well as essential chemical analysis, and logistic supports, which hardly exist, according to Cornia and Jolly (1987).

According to WHO (1995b) and Wall et al. (1996), there are three main national systems by which data are collected. These are

- food poisoning notifications (i.e., notification is based upon a clinical diagnosis);
- national surveillance schemes for a laboratory reporting system. Laboratory reporting is based on isolation of the causal organism by reporting species and subspecies and types of organisms. Laboratory data is used to monitor current trends, to analyses and to detect outbreaks, and
- national surveillance schemes for general outbreaks of infections. These include investigation about possible outbreaks or unusual occurrences.

Such systems should form a basis for the formulation of effective prevention and control strategies. Thus, foodborne disease investigations enable policy makers provide a basis for legislative actions and the development of intervention strategies and research investments.

According to O'Brien et al. (1998) three approaches may improve control of foodborne diseases. Firstly, the microbial quality of food needs to be improved by concerted action at all stages in the chain from the point of production to the point of consumption. Secondly, healthy behaviour needs to be fostered through education. Thirdly, further standardization of surveillance would make trends easier to identify.

D. Surveillance of foods, operations, facilities and equipment

A comprehensive surveillance of food, premises and equipment, and microbiological testing of products and their ingredients to ensure their safety for human consumption is recommended by the same authors (CAST, 1994; Guzewich et al., 1997; Todd et al., 1997). These surveys provides rate and occurrence of microorganisms in foods, therefore contribute to greater understanding of microbiological problems associated with food. There is no doubt that these approaches can be valuable, especially if properly planned and conducted, which is not easy under the severs resource constraints evident in Oman.

E. Regulation

Legislation

Food law is an expression of the seriousness of the government in assuring food safety and quality and to protect consumer. Legislation establishes the procedures to administer the law including the authority to promulgate rules and regulations for food quality standards, codes of practice and procedures governing food handling, processing, storage, shipping and sale (Jukes, 1993). It defines the role and authority of government organizations, agencies and institutions. It identifies the requirements and responsibilities of the food industry and the private sector. It provides for consumer redress procedure, and it establishes enforcement sanctions for non-compliance. Legislation also describe procedures such as those that may be required for approval of the use of food additives, packaging and labelling, food importing or exporting, registration of facilities and food product market withdrawal or recall. It authorizes food control officials to make investigations, to inspect facilities, to collect and test food product samples, to examine records, to detain or confiscate illegal or contaminated food, and to impose administrative sanctions (fines, licence suspensions, facility closures, etc) (Whitehead, 1995). A number of EU Directives, Regulations and Decisions, culminating in "Regulation No 178/2002 of the European Parliament and of the Council of 28 January 2002, laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety", are clear witness to the significance which societies now give to an adequate system of food law.

Problems relating to food laws and regulations in Oman range from an absence of specific laws for food safety, to lack of an adequate framework for enforcing them where they exist (see Chapter Eight for more details). Consequently, poor fish quality continues to cause significant economic burden to the Omani fish sector, as indicated in Chapter Four.

Enforcement

Enforcement activities include product inspection, process inspection, product recall, and legal action (including fines and criminal prosecution). Food sold, or processed for sale, should be fit for human consumption.

In the UK, the food safety legislation provides inspector authority for inspect and seize suspect food, when that food might cause poisoning or is failing to comply with safety requirements. An "improvement notice" can be given to food business whose is failing to comply with the law. The issue of such a notice provides an incentive for the business concerned to implement the specified improvements. Failure to do so would be consider as an offence. UK inspection statistics for 1996 show the number of prosecutions (572 out of 387,379 establishments inspected) and convictions (478) in 1996, continuing the downward trend of the previous five years (Anon, 1998). Establishments were primarily subjected to written warnings (16,711) followed by improvement notices (3,119), formal cautions (534) and emergency prohibition orders (110). There were 3,818 seizures and 147 closures of establishments during 1996. 35% of prosecutions were due to hygiene faults (e.g. handling procedures, condition of premises or equipment, temperature requirements) followed by 20% due to labelling and presentation faults of products, 12.2% due to extraneous matter in the product and 10.4% due to microbial contamination including moulds.

The goal of an inspection is two-fold, as argued by Bassett (1992): it is an enforcement mechanism and it should contain a health education element. Thus, initially the inspection allows the officer to evaluate the amount of legislation being enforced in the premises, and subsequently, the use of an improvement notice, which prescribes a period in which defects must be remedied, serves to promote health education.

F. Education and training activities

Training of food control personnel endeavours to emphasise the multi-disciplinary training for food safety. It is important for the personnel to understand the different factors affecting food safety control. There is, therefore, a case for post-experience courses in proper codes of conduct, understanding of food law and regulations and methods of enforcement, and the objectives and purpose of food safety control. For food inspectors training needs to cover their position as advisors as well as policemen.

The consumer finally chooses food products and prepares them for consumption. Consumers should be sufficiently aware of the nature and safety of the food they purchase, prepare and consume. If they mishandle food, the efforts of all other sectors are useless. Miyagishima et al. (1995) argue that consumers should not only adopt appropriate practices for food handling in the home, but also participate in wider activities to support governmental actions and become aware of food safety issues. Their awareness is essential in keeping policy-makers watchful about food safety matters and in promoting the highest standards by business. This is an approach which is need in of development in Oman.

G. Monitoring and evaluation

Food contamination monitoring has been defined by WHO (1993) as "a system of repeated observation, measurement and valuation, for a defined purpose, carried out on samples representative of individual food or diet in a country or a given area within a country".

Evaluation of monitoring results in assessment of the different aspect of food safety from food production, processing, storage, distribution, marketing and preparation for consumption. Sources and level of contaminants provide data for policies and legislation for effective food safety service. Continuous monitoring, re-examination and evaluation of the control system, as well as the level of contaminant, are required to ensure effective consumer protection and to ensure that the activities being undertaken are those that bring substantial improvement to the economic and social well being of the consumer.

2.6.3. Conclusion

A. Where to intervene

Mossell (1989) argues that integration, to be effective, should cover all phases, from the animal or vegetable raw materials to the plate of the consumer, which implies the integration of expertise of human and veterinary doctors, food scientists and agronomists for control of the microbiology and hygiene of foods. The sole aim is a gradual reduction of health hazards at all stages of production and processing until final operations (Sinell, 1995).

According to Abdussalam (1983), a careful assessment of the food chain, the local socio-economic conditions, the existing infrastructure and the resources availability for food safety control is paramount, if effective food safety control is to be achieved in countries with limited resources. WHO (1989a) has also stressed the importance of preparing and establishing a "Country Profile" or database which will help to identify priorities and provide a resource base for strategic planning for food safety control. Such a profile should evaluate existing infrastructure including food protection and consumption practices, food trade, infrastructure and facilities for control.

B. How to intervene

Governments should establish a food quality and safety and apply strategy throughout the entire food-production chain, starting at farm level with the application of good agricultural practices and good veterinary practices. Quality control, including good storage and transportation practices, good manufacturing practices and hygiene controls, continues through every segment of the food chain (storage, transportation, processing, packaging and labelling, handling and preparation of food).

The information and surveillance system for foodborne diseases is used to monitor and adapt the system.

Chapter Three

Impact of Council Directive 91/493/EEC on Selected Developing Countries

3.1. Introduction

Over the last 40 years, many major food importing countries have established strict hygiene regulations and legislation, including definitive standards for fishery products. Many countries exporting fishery products, particularly developing ones, did not have the mechanisms in place to meet such requirements. This led to rejection of consignments and economic losses, a fate suffered by Oman in 1997. Decomposition and the presence of pathogenic organisms or poisonous substances have been indicated as being the main reason for these rejections (Howgate, 1992). Howgate (1992) and Lima dos Santos (1992) have published comprehensive reviews on the status of inspection and quality assurance of fishery products in developing countries.

To gain access to foreign markets, exporting countries have to satisfy increasingly stringent requirements with regard to the quality and particularly hygiene and safety of food products. EU Council Directive 91/493/EEC of 22 July 1991 "laying down the health conditions for the production and placing on the market of fishery products" sets up the legal framework under which third countries may export to the EU, and the

Commission Decision (94/356/EC) lays down detailed rules for the application of Directive 91/493/EEC as regards "own health checks" on fishery products. Council Directive 93/43/EEC on the "hygiene of foodstuffs" is a general Directive covering all foodstuffs, and incorporates HACCP by name into the legal framework (Article 3.2).

Although the primary objective of the legislation is to harmonize practices within the Community, it is a principle of Directives that their provisions should apply to imports from third countries and that there should be a common import system applied by all Member States of the Community (as laid down in Chapter II of the Annex to Council Directive 91/493/EEC).

The legal and technical contents and implications of the EU's Directive have been reviewed by several authors (Ababouch, 1993; Belveze, 1992; Herborg, 1992; Howgate, 1992, 1993; Jensen, 1992). This principle of equivalence is also applied to imports into other countries receiving fishery products, particularly the USA by the Food and Drug Administration (FDA) and in Canada by the Inspection Services Branch of the Department of Fisheries and Oceans (DFO).

This chapter reviews the implications of the Council Directive 91/493/EEC and Commission Decision 94/356/EC on seafood products exported from selected third countries to the EU. As part of the background research for this chapter, the reports of Commission-appointed inspectors on the hygiene practices of a number of countries were reviewed. A summary of the results of that review is included in this thesis in Appendix IX.

Specific developing countries[1] have been chosen for more detailed investigation than the summary in Appendix IX in this study, primarily because of the availability to the researcher of relevant literature. The results of this desk study may be summarised as:

- The EU is an important market for these countries' exports of fish products during the period immediately prior to the introduction of the restrictions.
- Most of countries covered in this study have faced problems in exporting fishery products, in particular to the EU, and their traditional export markets. Areas of particular concern are poorly developed institutional and legal frameworks, weak technical regulations, substandard inspection and approval procedures, inadequate laboratory facilities, untrained officials, and poor levels of personal hygiene and sanitation (see also Appendix IX).

3.2. EU Legislation

Food inspection and quality control of fish and fishery products have a long tradition in Europe. They originate from medieval times when they covered a number of trade aspects related to the transport and sale of fish and fishery products. The type, weight and quality of products were strictly controlled in the different harbours and markets. For instance, in France a barrel of salted pickled herring could be closed only after visual approval of an inspector who would then apply the official village seal on the barrel's tap (Thomazi, 1947). EU countries have, since then, established a variety of hygiene and sanitary legislation, regulations, product standards, inspection structures and procedures, to control the production and trade of fish and fishery products within each country's territory. These initiatives have varied a great deal from country to country.

[1] Kenya, Mozambique, Morocco, Thailand

The EU enacts three types of legislation:

- Regulations: a Regulation is a law that is binding and directly applicable in all Member States without any implementing national legislation. Both the Council and the Commission can adopt Regulations. Since 1995, the European Parliament has shared a co-decision role with the Council.
- Directives: a Directive is a law binding on the Member States as to the result to be achieved, but the choice of method is their own. In practice, national implementing legislation in the form deemed appropriate in each Member State is necessary in most cases. Thus businesses affected by a Directive have to take account of the national implementing legislation as well as the Directive. All Directives set a date by which Member States have to transpose it into national legislation. After that date, in case of non-implementation, the Directive remains the basic reference point in the case of dispute. The Commission can act against Member States that have not implemented the directive in time.
- Decisions: a Decision is binding entirely on those to whom it is addressed. No national implementing legislation is required. Both the Council and the Commission can adopt Decisions. Since 1995, the European Parliament can be associated with to the adoption process on a limited number of issues.
- Recommendations: a Recommendation has no binding effect (as it is not a law). Both the Council and the Commission can adopt Recommendations (e.g., Commission Recommendation 92/540 concerning a coordinated programme for the official control of foodstuffs for 1993).

In July 1991 the European Union issued the Seafood Directive (91/493/EEC) seeking to harmonise the seafood safety standards of its member countries.

The Seafood Directive has a detailed Annex regarding conditions and standards. Subsequent to the adoption of the Seafood Directive, there have been Directives and Decisions that provide further details for the implementation of the Seafood Directive. Also, the Seafood Directive has a companion Directive related to live bivalve mollusc (91/492/EEC).

The Seafood Directive creates the requirement that seafood processors carry out their "own checks" to assure seafood safety (Article 6). "Own checks[2]" is close in concept to a HACCP system. The detailed application of "Own Checks" is set out in a 1994 Commission Decision (94/356/EC).

Through the Seafood Directive, its Annex and subsequent Decisions and Directives, the EU Council has created a system which places responsibility for seafood safety on the processors, the Member States of the EU (i.e. the competent authority within each of the States) and the European Commission.

It is the responsibility of the competent authority within each of the EU members to ensure that the persons responsible for "establishments" (defined as being any premises where fishery products are prepared, processed, chilled, frozen, packaged or stored (see Art. 2 (15)) comply with the specifications of the Seafood Directive. The Seafood Directive creates specifications regarding:

[2] The "own checks" system laid down in Article 6 of Directive 91/492/EEC is not yet a fully HACCP system, but it is the legal basis for one. The "own checks" system was elaborated in Commission Decision 94/356EC of 20th May 1994 laying down detailed rules for the applications of Council Directive 91/493/EEC. This Decision makes the point at which HACCP fully became the officially recommended technique for meeting the terms of Directive 91/493/EEC.

- harvesting and the handling of fish on board vessels (Chapter I of the Directive Annex, and Council Directive 92/48/EEC respecting minimum hygiene rules on certain fishing vessels);
- handling during and after landing (Chapter II of the Directive Annex);
- the establishments in which processing can take place (Chapter III of the Directive Annex);
- handling, packaging, preparing, processing, freezing, defrosting or storing in processing establishments (Chapter IV of the Directive Annex);
- parasite checks (Chapter IV, section V of the Directive Annex and Commission Decision 93/140/EEC respecting visual inspection for parasites);
- packaging (Chapter VI of the Directive Annex);
- identification marks (Chapter VII of the Annex); and
- storage and transportation (Chapter VIII of the Annex).

Chapter V of the Directive Annex provides that the competent authorities of the Member States are to arrange for general monitoring (checks) through inspection to ensure compliance with the above obligations.

Article 3 (d) of the Seafood Directive (91/493/EEC) provides that fishery products are to undergo health checks in accordance with Chapter V of the Directive Annex. Health checks are the responsibility of the competent authority of the EU Member State. The health check involves the monitoring of the specifications as noted above plus, through sampling, organoleptic checks (freshness), parasite checks, chemical checks (histamine) and microbiological analysis, plus contaminants analysis. There are specific standards regarding histamine, for example, including the requirement that nine samples must be taken from each batch (See Chapter V (3)(4)(b) of the Directive Annex and Chapter 2.

section 2.2.1 B of this thesis). For freshness, the standard is fitness for human consumption and the test employed is sensory evaluation.

Processing and activities related to it may only take place in establishments that have been approved by the competent authority of a Member State (Article 3 (c) and 7 (1)). Once approved, the product from an establishment can circulate within the EU, subject to the continuing health checks described above. The approval of an establishment takes place only when the competent authority verifies that the requirements of the Seafood Directive (the relevant specifications including the HACCP system to be discussed below) have been met. Inspection and monitoring of approved establishments by the competent authority of the Member State is to take place "regularly" (Article 7 (4)). Experts from the Commission may conduct on-the-spot checks to verify that establishments are complying with the requirements of the Seafood Directive (Article 8).

Own Checks

Whilst it is the responsibility of a Member State to ensure that processors comply with all the relevant standards and specifications, the processor must assist with the compliance/enforcement task by developing and implementing a system of critical point identifications and formal monitoring (Article 6). A key component of the above-noted approval process for a seafood processing establishment is satisfying the competent authority of the existence of an effective "own checks" system.

Detailed instructions for identifying critical points are provided in Chapter 1, Annex of Commission Decision 94/356/EC regarding own health checks on fishery products (see also Article 6, para. 2 of the Seafood Directive and Article 2 of the "Own Checks" Commission Decision). Monitoring and checking critical points, recording the monitoring results and verifying that the control system is performing effectively are also detailed in the Annex of the "Own Checks" Commission Decision. The "Own Checks" system is obligatory for a processor to become an approved establishment.

Import procedures from third countries

For seafood to enter the EU, processors must have effective HACCP systems in operation, and a competent authority (institution or body) in the government of the exporting state to assure compliance with the EU Seafood Directive. A statement from the exporting state saying that it is complying with the EU Directive is not sufficient. The EU must be convinced through its own investigation and local inspection that equivalency is being achieved.

Experts appointed by the Commission visit states which export seafood to the EU to determine the specific conditions that should be fixed for seafood from that exporting country (Article 11 (1) and (2)). In fixing such conditions (determining equivalency) account is to be taken of:

- the legislation of the exporting state;
- the organisation of the exporting state's competent authority, its inspection services and its powers to verify implementation of legislation;
- the actual health conditions during production, handling and storage of product destined for the EU; and
- assurances that can be given by the exporting state of compliance with checks and monitoring requirements set out in Chapter V of the Annex to the Directive.

The best outcome from an exporting state (and thus exporting processors') point of view is to have the Commission experts find that a country's laws, seafood safety standards, actual health conditions and the inspection procedures used by the exporting state's competent authority are equivalent to those within the EU.

An exporting country which has met the equivalency test becomes an approved country or a country from which seafood imports are authorised. (See, for example, Commission Decision 97/296/EC drawing up the list of third countries from which the import of fishery products is authorized for human consumption.)

An exporting state which has been approved as having equivalent standards prepares a list of approved establishments (export processors). No establishment should appear on the list unless the competent authority in the exporting state approves its inclusion, taking into account the requirements that the establishment is monitored "by an official inspection service" and that it complies with requirements equivalent to those in the Seafood Directive (Article 11 (4), para. 2). Each establishment is to be "registered and approved" by the Commission (Article 11 (4) (e)) and to have an individual number which is to be placed on all fishery products exported to the EU. A health certificate issued by the exporter's government should also accompany consignments to the Community. The Commission can conduct inspections and visits to processing plants within approved or authorised states in order to ensure that compliance is continuing.

3.3. Impacts of import restrictions of EU on fisheries products

Stringent hygiene and sanitary requirements in developed countries, in particular provisions concerning the use of HACCP, have affected marine exports from several developing countries. Failure to comply with such requirements has resulted some countries not qualifying for exports to the EU. In addition, the EU has imposed bans on the imports of fishery products originating from certain developing countries, for example Bangladesh and Oman (1997), India (1997), Mozambique (1997), Uganda (1997 and 1999), Kenya (1997 and 1999), and the United Republic of Tanzania (1997 and 1999). These bans have subsequently been lifted, but may have long-term effects on the countries concerned (arguably beneficial in many cases). Particular attention is paid to the difficulties to comply with such requirements and compliance costs.

In April 1997, the Commission decided that as of 1 July 1998, fish and fishery products could be imported only from a specific countries (Decision 97/296/EC, of 22 April 1997). This list contains two of groups of countries:

List I: consists of countries which are approved to export fish and fishery products to the EU ("EC-harmonized countries"). This list contains for example Oman.

List II: consists of countries that are not yet covered by a specific decision but qualify under Article 2 (2) of Decision 95/408/EC as "provisionally-approved" countries. Imports may be allowed over an "interim period" (this period currently expires in December 2003). While imports from List II countries are authorized, each EU member state can still impose its own specific import conditions and can handle its own list of approved establishments. Commission Decision 95/328/EEC establishes that health certification is required for fishery products from third countries on List II.

In this section, the impact of the EU measures on selected developing countries is discussed.

3.3.1. Kenya

The EU is an important market for Kenyan exports of fish, accounting for 59% of exports by volume during the period immediately prior to the introduction of the restrictions. Kenya experienced a number of problems gaining approval from the European Commission to export fish to the EU (see Table 3.1). It did not obtain List II status until January 1999 (see Kenya entry on Appendix IX). A number of other developing countries, including Kenya's neighbours, Uganda and Tanzania, experienced similar problems. Since 1997, the Commission has undertaken a series of inspection visits to Kenya and has subsequently questioned the procedures by which plants are approved for export to the EU. An area of particular concern is the hygiene standards on boats and at landing sites, many of which lack jetties, potable running water, cooling facilities, fencing, etc., as reported by Mussa (2001), as well as inadequate monitoring procedures.

Since 1997, Kenya (along with Tanzania and Uganda) has been subject to two phases of restrictions on exports of fish, especially Nile Perch (*Lates niloticus*), to the EU (Henson, et al., 2000). The first phase started in April 1997, following border inspections indicating that consignments of Nile Perch were contaminated with *Salmonella*. Subsequently, all consignments of Nile Perch were subject to border testing for *Salmonella*, the cost of which was borne by the importer. In December 1997, these problems were exacerbated by an outbreak of cholera in East Africa, as a result of which the EU subjected consignments of fish to border testing for *Vibrio cholera* and *Vibrio parahaemolyticus*[3] (see Table 3.1). Because of the time taken for these tests to

[3]These measures were subject to criticism in the WTO's SPS Committee, in particular through a statement tabled by the World Health Organization (WTO 1998).

be undertaken, exports of fresh fish were subsequently prohibited. These restrictions remained in place until June 1998.

The second phase of restrictions started in April 1999. This followed reports of fish being poisoned with pesticides in Lake Victoria, as a result of which Uganda voluntarily suspended exports to the EU in March 1999. Although Kenya (and Tanzania) adopted precautionary measures in an attempt to prevent contaminated fish from entering the supply chain, these measures were not deemed adequate by the Commission, and a ban on exports of fish from Lake Victoria was implemented. The European Commission subsequently undertook an inspection visit to Kenya to assess the monitoring and residue-control program that the government established (see Appendix IX).

The fish processing subsector is reported to have been affected by the EU's restrictions on exports (Geheb 1997, Mitullah, 1998b; Abila and Jansen, 1999).

The Kenyan Government undertook a number of initiatives to address the concerns of the Commission in an attempt to have the restrictions suspended and ultimately to get full (List I) approval for the export of fish to the EU. These involved the introduction of legislative changes, the reform of procedures for the approval for exports of fish to the EU and the issue of health certificates. Regulations were introduced to ensure hygienic fish handling and processing, in order to assure the safety of Kenyan fishery products. After the publication of the Fisheries (Fish Quality Assurance) Act, the Ministry of Agriculture and Rural Development whose mandate is to ensure food safety, quality and security, became the competent authority for fish and fishery products.

There have been some positive developments in the industry (as reported by Mitullah 1998b):

- A code of practice has been established;
- Quality assurance programmes for exports have been developed;
- Health conditions at landing sites have been improved;
- Capacity to analyse fish/fish product samples has improved; and
- Industry quality managers and fish inspectors have been trained.

The Kenya Bureau of Standards has published a code of hygiene practice for the handling, processing, and storage of fish, which applies to all fish for both export and the domestic market. This standard harmonizes Kenyan hygiene requirements for fish with those of the EU. In addition, the Fisheries Department is reported to have planned various institutional mechanisms to improve the hygiene at fishery landing sites.

3.3.2. Mozambique

The Government of Mozambique has responded very positively to the new international trade regime. It as undertaken a number of initiatives to address the concerns of the Commission and to export deep frozen shrimps to the EU (Mussa 1998). These include the introduction of fish legalisation and inspection, the provision of inspection and technical services to factories and vessels, training for fish inspectors at all levels, enhancement and definition of the role of laboratories, an adapted HACCP system for Mozambique's own requirements, which, *inter alia,* cover sanitary conditions and plans for fishing vessels, the establishment of the Department of Fish Inspection as the competent authority within the Ministry of Fisheries, and putting in place a fisheries law which aims to guarantee the safety of exported fishery products. Mozambique is currently on List II of approved countries.

The Fisheries law also has provisions for (as reported by Mussa (1998)):

- Analysis and approval of projects to set up establishments for processing of fish products;
- Approval of hygiene/sanitary conditions, hygiene and quality control programmes of factories/vessels;
- Certification of fishery products aimed for export;
- Laboratory control for fish inspection programmes;
- Organization of trading/extension programmes for the technical personnel of the Fish Inspection Services and Industry;
- Promotion of research programmes.

3.3.3. Uganda

Following successive bans of fish exports to the EU, volumes and earnings were severely curtailed, and negative effects on the fishing communities and overall economy ensued. Henson et al. (2000) estimate that the loss of income to the catching subsector due to a typical ban is about $1.0 million per month. During the ban, out of 11 factories which were operational at that time, three were closed and the remainder were operating at about 20 per cent capacity which resulted in 60-70 percent of the directly employed people being laid off. People involved in the various fishing activities became jobless and those that had some work to do earned less than a third of their normal earnings. This directly affected families and dependants of people involved in fishing and supplementary activities. Other related industries, such as packaging, transport and the overall economy, were affected, as reported by Henson et al. (2000).

As a result of the ban, government and fish exporters were compelled to upgrade fish handling facilities, including lake fishing gear, transporting boats' containers, landing sites and factory floors and other facilities (see Table 3.1). Specifically, a microbiology laboratory had to be fully equipped. $180,000 was invested in a monitoring programme on Lake Victoria and 10 inspectors were recruited to supervise fish production at factories. In order to create capacity to analyse pesticide residues, a privately run laboratory was set up.

In 1998, Uganda was placed on List II of the countries authorized to export fisheries products to the EU (Commission Decision 98/419/EC). Subsequently, as a result of investments in upgrading facilities at all levels of the fish production/marketing chain, Uganda was promoted to List I in May 2001. Factories are now reported (Mussa, 2001) to be operating at full capacity, implying increased direct employment in supporting services as well.

Although Uganda suffered from a loss of foreign exchange and reduced economic activities from the bans, some positive developments emerged from this experience, namely:

- The experience of the ban encouraged the authorities to focus on problems of the fish sector;
- The fish inspection services have been streamlined and the capacity of the competent authority strengthened;

- A fisheries policy has been formulated; inspectors trained; equipment provided and fish inspection manuals developed;
- Uganda' s fish gained access to the US market which demanded approved HACCP systems from the fish factories;
- Internationally recognized laboratory services have been established locally, which will facilitate export of other products and reduce costs;
- Ugandan consumers have benefited from the investment in a better sanitary system for fish harvesting and processing.

Table 3.1. Reasons of EU imposed import restrictions on Kenya, Tanzania, and Uganda

Issue	Countries affected	Measure taken	Source
Presence of *salmonella* in Nile perch from Lake Victoria	Kenya, United Republic of Tanzania, Uganda	Each consignment of Nile perch fillets tested for the presence of *salmonella*	Commission Decisions 97/272/EC (Kenya), 97/273/EC (Uganda) and the United Republic of Tanzania (97/274/EC) of 4 April 1997 (Official Journal L 108 of25 April 1997)
Outbreak of cholera	Kenya, Mozambique, United Republic of Tanzania, Uganda	Each consignment of frozen or processed fishery products subject to checks capable of detecting, in particular, the presence of *salmonella* and *vibrionaceae (vibrio cholera* and *vibrio parahaemolyticus);* Prohibition of imports of fresh fishery products (because of time required to carry out microbiological analyses)	Commission Decision 98/84/EC of 16 January 1998 (Official Journal L 015 of 21 January 1998)
Fish poisoning caused by the presence of pesticides in the water of Lake Victoria and by fishery malpractice	Kenya, United Republic of Tanzania, Uganda	Suspension by Uganda of exports to the European Union of fishery products caught in Lake Victoria (precautionary measures by Uganda itself). Suspension by the European Union of fishery products caught in Lake Victoria from Kenya and the United Republic of Tanzania	Commission Decision 1999/253/EC of 12 April 1999 (Official Journal L 098 of 13 April 1999): restrictions on imports from Kenya and Tanzania

3.3.4. Bangladesh

Bangladesh's frozen shrimp and prawns exports represent 2.2% to 3.0% of the volume and 2.1% to 2.7% of the value of worldwide shrimp exports (Cato and Lima dos Santos, 1998). Shrimp represent about 90% of the value of Bangladesh's marine product exports, and are an important source of foreign exchange to the Bangladesh economy. Major markets for Bangladesh shrimp are EU, US, and Japan. Bangladesh's shrimp exports have experienced safety and quality problems including detentions for inspection in the U.S., and a ban on imports into the EU. The 1997 European Commission ban on seafood imports into the EU from Bangladesh is estimated to have cost shrimp processing sector up to of US$14.665 million in lost revenues (Cato and Lima dos Santos (1998)).

By the end of the 1970s, the Bangladesh seafood processing industry began to expand rapidly, but the use of new technology, sanitary facilities and processes, and trained manpower at the worker and management levels did not keep pace with this rapid growth. As a result, the export of frozen seafood suffered considerably from 1975 to 1978, as seafood imports from Bangladesh were placed under automatic detention by the United States Food and Drug Administration (Ahmed 1998). FAO has recognized the need for improvements in Bangladesh seafood safety and quality, with missions there in the early 1980s to assist it in the development of national fishery product standards, regulations, and fish inspection schemes. In 1983, the Bangladesh Government enacted a Fish and Fish Product Ordinance (Inspection and Quality Control), and, in 1985, the quality control laboratory was up-dated and additional personnel hired.

During 1997, a total of 143 shipments of frozen shrimp from Bangladesh into the US were automatically detained without examination. Eighty-seven percent of the shipments were detained between September and December, when most Bangladesh shrimp are imported. The reasons for the 143 detentions were as follows: filthy, *Salmonella* (53); soaked, wet, filthy, *Salmonella* (28); *Salmonella,* decomposed (21); *Salmonella* (14); filthy, insanitary manufacturing, processing or packing (8); filthy (8);

soaked, wet, *Salmonella* (5); filthy, *Listeria,* insanitary manufacturing, processing or packing (3); soaked, wet, filthy (1); filthy, label not bearing nutrition information (1); soaked, wet (1). Automatic detention does not mean that the product is rejected. It means that each shipment is inspected and then allowed into the US if the product is safe and meets minimum safety standards.

In contrast to the EU and US, government authorities in Japan have not recorded recent problems at the time of import entry with shrimp from Bangladesh, although industry representatives have expressed concern. For the three-year period 1995 to 1997, no violations of Japan's food sanitation laws were recorded for shrimp imported from Bangladesh (Hiroyuki 1998).

On July 30, 1997, the European Commission banned imports of fishery products from Bangladesh into the EU (Commission Decision 97/513/EEC) as a result of European Community inspections of seafood processing plants in Bangladesh. The concern resulted from serious deficiencies in the infrastructure and hygiene in processing establishments and because there were not enough guarantees of the efficiency of the controls carried out by the competent authority (Bangladesh government inspectors). The Commission decided that consuming fishery products processed in Bangladesh posed a significant risk to public health.

Subsequent inspections and decisions recognized the Bangladesh Department of Fisheries, Fish Inspection and Quality Control, Ministry of Fisheries and Livestock as the competent authority in Bangladesh. They also indicated that Bangladesh quality assurance legislation was equivalent to that of the EU. Subject to certain provisions, the ban was lifted on seafood product imports from Bangladesh for six approved establishments for products prepared and processed after December 31, 1997 (Commission Decision 98/147/EEC). In 1998 the European Commission approved a total of eleven Bangladesh plants for export to the EU.

The Department of Fisheries has adopted HACCP as the principal programme used to monitor the seafood processing industry for safety and quality. HACCP was implemented nation-wide in December 1997. According to the Department of Fisheries, the quality of seafood products has improved and systematic hygienic operating systems are being followed by the seafood processing plants (Ali 1998). According to Cato and Lima dos Santos (1998), the Department of Fisheries has spent US$201,483 through December 1997 to upgrade its laboratories, hire additional employees and train employees in order to achieve acceptable levels of technical and sanitary capabilities in its monitoring programme. The principal costs are for new equipment and laboratories. Cato and Lima dos Santos estimate that US$ 180,676 was spent in 1998, principally for new employees and laboratory chemicals and glassware. An estimated US$ 225,039 will be spent annually each year after, mainly on the salaries of new employees.

3.3.5. Thailand

The Thai seafood industry has become a large supplier to most major markets, such as the US, the EC countries and Japan. Markets have also expanded in Canada, Australia and the Middle East countries. As the volume of trade and production expanded, problems relating to the safety and quality of the products required greater attention so as to provide assurance that products processed by Thai processors were safe, of good quality, and otherwise met the requirements of importing countries.

The Fish Inspection and Quality Control Division of the Department of Fisheries (DOF) provides fish inspection and quality assurance services (Chansiri, 1996). Processing plants intending to export to the North American and European markets are subjected to inspection by DOF. The Division found that traditional inspection had certain limitations, one of which was the rapid turnover of personnel. Inspection of facilities and operations are carried out with reference to various guidelines, standards and codes of practice.

The HACCP principle was introduced to the Thai canning industry in 1985. From 1991 to 1995, the Department of Fisheries started a voluntary fish inspection programme for the fish processing industry. Chansiri (1996) reports that in 1996 HACCP became mandatory for fish processing establishments approved for export by the Department of Fisheries. Since January 1st of 1996, the goals of HACCP implementation, as summarised by Chansiri (1996) are:

- avoiding the many weaknesses inherent in the traditional end-of-line inspection approach;
- increasing the level of assurance and confidence of the authorities in importing countries in the fish inspection quality control services provided by the Department;
- preparing for a new approach for fish inspection based on HACCP principles to be applied by major trading partners;
- increasing private sector involvement and responsibilities in fish quality assurance programmes;
- reducing the rate of end product sampling and certification.

The industry is responsible for:

- instituting prerequisite programmes and a programme of regular inspection at critical control points for each operation;
- verification of HACCP plans and prerequisite programmes;
- establishing appropriate guidelines for each critical control point, identification of hazards, preventive measures, monitoring procedures, critical limits, corrective actions and verification;
- establishing a system of record-keeping to indicate instances of non-compliance, corrective actions and verification taken.

The Department of Fisheries conducts seminars, workshops and training for government and the private sector on the principles and application of HACCP. HACCP Training Modules are developed to train industry personnel in developing quality programmes and quality manuals and to strengthen the processor's ability to conduct monitoring and verification. The DOF assesses the HACCP programmes of the processing plants in three ways:

- verifying the documented programme as relevant to the processing conditions of the establishment;
- conducting independent inspection of products and facilities; and
- auditing the plant's quality management activities at critical control points (Chansiri (1996)).

3.3.6. Morocco

As a result of the new Sanitary Directives (91/492/EEC and 91/493/EEC) and the Decision 94/356/EC, Morocco developed a strategy to meet EU standards, as summarised by Ababouch (1996):

- Fish inspection legislation has been revised and is being updated to include mandatory in-plant HACCP-based quality control programmes and defining requirements for private laboratories that are certified to carry out quality control activities.
- Fish inspectors underwent training programmes on fish processing technology and quality control.
- Inspection laboratories, facilities and equipment have been upgraded to meet the new challenges.

The industry initiated a programme to upgrade processing and packing facilities in order to meet the EU requirements of sanitary layout and construction and to train workers to enforce hygienic practices and sanitation.

Following these activities, EU experts visited Morocco in late September 1995 to assess the national fish inspection and quality control programme at both the Government and industry levels (see Appendix IX). The Moroccan inspectorate was certified as capable of carrying out the implementation of the EU sanitary regulations. A Decision (95/30/EEC) was issued in this respect on 2nd of October 1995. However, all exporting fish processing plants were requested to implement HACCP-based quality control programmes no later than June 30, 1996.

The competent authority, along with the industry, organized several workshops and training courses on HACCP development and implementation. Courses were organized (1995 and 1996) to train more people with the help of local and outside expertise, including FAO, UNIDO, US and Canada.

In addition, the inspection services and local technical support project prepared documents to assist the fish industry in developing and implementing HACCP plans. The project provided for supporting activities, such as the development of HACCP programmes, training technical persons and the verification auditing of in-plant quality control programmes.

Certain characteristics of the conditions of the Moroccan fish industry have been taken into consideration in setting the Morocco HACCP programmes (see Table 3.2) The HACCP programme starts at the fish receiving stage at the cannery to meet the requirements of the processors who do not have much control over handling practices on-board.

Table 3.2. Application of HACCP principles to the fish canning industry in Morocco (Ababouch, 1996).

Hazard analysis	A complete hazard analysis was carried out based on epidemiological data, consumer complaints and other control results compiled by the industry and the inspection services over the years. The hazard analysis showed that the control of some hazards, such as botulism, are the sole responsibility of the processors, while other hazards, such as histamine poisoning or microbial induced spoilage, are the responsibility of both fishermen and processors. The third type of hazard, namely the presence of unacceptable levels of mercury, requires the collaboration of the fishermen, the national pollution surveillance programme managers and the processors.
Identification of critical control points (CCPs)	The Moroccan fish canning industry used the Codex Alimentarius decision tree to identify CCPs in their processing.
Establishment of critical limits (CLs)	For each of the measures identified to prevent/control a given hazard, critical limits were established to indicate whether the preventative/control procedures were correctly applied. In this regard. GMPs and international guidelines were used to establish CLs for double seaming analysis and sterilization.
Establishment of monitoring procedures	Various monitoring procedures were considered and the most applicable ones were chosen in order to assess whether CLs were met. Attempts were made to build on the monitoring procedures already operational in many canneries and to structure them more easily and quickly. Also, the applied research on histamine and TVN (Total Volatile Basic Nitrogen) accumulation kinetics allowed the development of predictive models.
Establishment of corrective actions	Practical and applicable yet efficient corrective actions were identified and evaluated. They specifically describe how to rectify the situation and what to do with the fish processed since the last verification.
Verification of the HACCP programs	The Moroccan competent authority evaluated and revised the HACCP system after 6 months of implementation during the first year and continue to do so every year thereafter. For each plant, the verification/evaluation procedure targets the following: Processing of consumer and client's complaints Processing of the fish inspection control data Processing of the factory in-plant controls External auditing if needed
Record-keeping	Recording systems were designed to suit the needs of each plant in terms of reporting HACCP relevant data. These include the HACCP manual which describes how principles one to six were to be implemented by each plant. Key people who will be in charge of well-defined preventive, control or corrective actions are identified and their tasks well-defined in the manual. Record systems include a set of forms where the results of daily checks verifications and corrective actions are reported.

3.3.7. Brazil

The regulatory governmental agency (Federal Inspection Service (FIS), Ministry of Agriculture)) decided to implement, with the Fishery Industrial Sector, the HACCP system in 1991 (Da Costa, 1996). This decision was officially sanctioned by the Brazilian Government in 1993, through administrative Directive No.23 (1993) (see Table 3.3). Three states (Cearra, Rio de Janeiro and Para) were chosen because of their large number of plants that produce frozen fish, crustacean, and canned and fresh fish.

The implementation of the Brazilian HACCP Programme, summarised by Da Costa (1996), involved the following:

Training: The government and the industry have been sponsoring training courses in inspection, quality assurance, technology and HACCP Principles. FAO/UN and NOAA/US gave support to the important training courses in these fields of study, and to some national research and training institutions.

Regulations: Among the Directives issued by the Federal Inspection Service of Fish and Fishery Products for the establishment of the HACCP system in the national fishing industry, was the Administrative Directive No. 23, of the Ministry of Agriculture's Executive Secretary of 12th of December 1993, which instituted the Technical Committee, formed by government inspectors from various regions of Brazil.

After implementation of the HACCP System, the Federal Inspection Service conducted audits to verify that was working. The audits were carried out by at least two trained

Federal Inspectors who were members of the Technical Committee, which had the responsibility for the implementation of the HACCP System.

A manual of procedures to implement the HACCP system in the fishery industry was prepared by the FIS, in association with other national and international institutions. This document was to help plants that were not able to develop and implement their own quality assurance programme. An audit manual was also designed for auditors (Federal Inspectors and Industrial Internal Auditors) to provide directions for the evaluation and the effectiveness of the HACCP programme. Instructional videos were developed in the fields of inspection, technology and quality assurance to emphasize the HACCP principles in the fresh, frozen and canned fish processing sector.

The FIS developed MOUs (Memoranda Of Understanding) with the Inspection Services of trading importing countries. The MOUs embody an agreement that the foreign governments of countries exporting to Brazil are responsible for evaluating their own processors' HACCP plans, inspecting foreign processors, periodically analysing products produced by these processors, and issuing health certificates. The Brazilian FIS, however monitors the effectiveness of the enforcing government's control programme in accordance with the established MOUs and supplies the Brazilian authority with periodic lists of processors that meet the requirements of the bilateral documents.

A total of 101 companies presented their programmes, based on HACCP principles. Out of these, 84 were preliminarily approved and 17 were not approved by the FIS. The main feature of the Brazilian HACCP Programme is summarised in Table 3.3.

Table 3.3. The official HACCP programme in Brazil

identification of the responsible staff for the elaboration and establishment program,
identification of the company,
organization chart of the company,
definition of functions and attributes of the staff in the organization chart,
curricular documents of those responsible for the HACCP program management,
technical program,
hazard analysis,
critical control point,
product flow diagram,
identification of the critical control points,
establishment of preventive actions,
establishment of critical limits,
monitoring procedures,
corrective actions, records,
summarizing table,
establishment of an effective record-keeping system,
verification of procedures internal audit,
hygiene control program,
recall procedures,
procedures over complaints of consumers and/or importers.

The principal problems and difficulties associated with implementing the HACCP system in the Brazilian Fishery Industrial Sector are summarised by Da Costa (1996), as follows:

- Raw material losses are sustained after capture, caused by improper handling, storage or conservation in fishing boats;
- The long period between the capture and the unloading of a ship, in most regions of Brazil, causes a decrease in the quality of fresh fish;
- The quality control programmes in some Brazilian plants are still focused on final product control, instead of dynamic process control;
- It is not easy for the government to manage the inspection and quality assurance system, due to a reduced number of federal inspectors and an increasing number of plants;
- Fishery products of non-uniform quality are still traded;
- Fraudulent practices in the fish trade market are still detected;
- There is a lack of efficient sanitary control of molluscan shellfish.

3.3.8. Malaysia

The Ministry of Health (MOH) has implemented the HACCP system in the food industry since 1995 (Merican, 2000). As of mid-1997, the MOH established a third party auditing procedure, based on the (ISO) system used by the Malaysian Standard Department. The MOH acts as the certification body for HACCP.

Besides the MOH, the Department of Veterinary Services (DVS) is involved in HACCP for slaughterhouses and livestock farms, while the Department of Fisheries (DOF) is involved with that for fisheries and aquaculture. Government agencies such as the universities provide consultation and training in HACCP.

Applications for HACCP certification are made to MOH. The MOH replies with a copy to the Malaysian Agricultural Research and Development Institute (MARDI). MARDI submits a quotation to the company. Once agreed, the two parties set a date for the audit. Each audit is performed by a team of two auditors, the lead auditor and a process specialist. Prior to this, MARDI performs an adequacy audit based on the written submission of the company's HACCP document, including the HACCP plan. The company is alerted before the audit visit. The auditors make preparation for the audit, including the checklist and Corrective Action Request (CAR) forms (see Table 3.4.).

The audit proper consists of the entry meeting, going through the documentation and updates, making a round of observation of the actual processing, checking all HACCP related records, and concluding with the exit meeting where CARs are issued, and signed by the company. The HACCP audit report is completed as soon as the auditors have received an indication of the dates when the corrections will be completed. A copy of the report is sent to the MOH for their records, and a copy is sent to the company.

A follow-up audit is performed by one of the auditors, after all corrective actions have been implemented. The auditor will recommend to the MOH to issue the HACCP certificate if the follow-up audit is satisfactory. The certificate will be valid for a period of one year. The MOH will carry out verification at a predetermined frequency based on the recommendation of the auditors.

Table 3.4. The MOH HACCP criteria for certification and documentations (Merican (2000)).

Criteria for certification	HACCP documentation
must have licence from Local Authority for operation, company must be registered with the Registrar of Companies, must have in place effective pre-requisite programmes, HACCP document available, HACCP system must have been implemented, product for domestic market must comply with Malaysian regulatory requirement, and product for export must comply with importing country's requirement.	Company profile, Management commitment to safety -policy and objectives, endorsement, HACCP team members -qualification and job specification, Scope of HACCP certification, Product description and intended use, Plant layout indicating process flow, Flow diagram including on-site verification, Hazard analysis worksheet, The seven principles -HACCP plan, Management review, Pre-requisite programmes -GMP, hygiene and sanitation, environment control, and Training policy.

Standardization of HACCP: To ensure standardisation of HACCP understanding by all parties the Standards and Industrial Research Institute of Malaysia (SIRIM) has formed a working group, comprising of relevant government departments, universities and industry, to formulate Malaysian guidelines based on the Codex Guideline of HACCP and its implementation.

HACCP Committee: The Ministry of Health has formed a committee on HACCP comprising all relevant government departments, universities and industry. The main objective of this committee is to overcome over-lapping of functions among different government departments.

Training in HACCP: The MOH and MARDI conduct joint courses on HACCP verification and auditing, and HACCP implementation. HACCP auditors must pass the HACCP verification and auditing course. The universities, DOF and DVS also conduct regular courses. DOF also participates in the HACCP curriculum under the ASEAN Fisheries Programme.

3.3.9. Oman

Oman established a market for its fish products, including a market for fresh, chilled and frozen fish before current national and international quality standards were formulated. When EU standards were established, Oman had no prior national standards in place to satisfy the requirements of the EU market. The threat to the Oman fish exports had already been drawn to the attention of fish processors and the government as early as 1992. Additionally, due to the large investments required to improvement to the fish handling and processing facilities, the industry delayed paying attention to the EU Seafood Directive since the importers (EU) continued to accept their exports.

The development of seafood processing and quality control in the Sultanate of Oman can be summarized:

- In the early 1970s the government constructed and operated fishery product processing plants in major communities in the Sultanate in an effort to diversify the sources of income and to rationalize the use of national wealth. These processing complexes were equipped with cold storage and ice plant facilities to be used by fishermen in order to preserve the quality of fish.
- In the mid-1980s, these public facilities were privatised. Fish exports had increased into traditional markets (i.e., Arabian Gulf Countries) as well as to Europe, Asia and North America. At this stage, however, quality control was not a concern.
- In the 1990s,as a result of the expansion of fisheries exports and the increased demand for quality, the Sultanate put greater emphasis on quality control to ensure continuous acceptance for its products in international markets. To show commitment to quality, the Ministry of Agriculture and Fisheries (MAF) established a Quality Control Section (QCS). The main mission of the QCS was to develop quality control measures to be implemented by processing plants wishing to export to international markets. This effort has resulted in the Quality Control Act for seafood exports, issued first in 1997 (QCA-97).

QCA-97 presents general procedures and standards for fish processing plants that intend to export fish. (EU requirements are summarised in Appendix X.) Its provisions cover hygienic regulations for plants and their personnel, including buildings, equipment, transporting, labelling, inspection and sample testing. Finally, it sets specifications for fresh and frozen fish for exports.

The role of the QCS is to enforce these regulations through on-site inspections. Fish processing companies wishing to export are required to comply with QCA-97 and obtain a quality control number.

QCA-97 is enforced through regular inspections carried out by QCS agents. Although the QCA-97 does not specify the number or rate of inspections, it is normally expected that inspections should be carried out 2 to 4 times per year for each plant. Inspections are done based on a sanitation compliance checklist, which includes building constructions, equipment and transportation facilities (Article 1), general hygienic conditions (Article 2), and the preparation and handling of samples (Article 3). The checklist is filled in and a quality rating is assigned. All records of the inspections are kept in the QCS.

The QCA-97 has helped many companies to upgrade their hygiene conditions, but not to the level required under a HACCP system, as implied by Council Directive 91/493/EEC and Commission Decision 94/356/EC, and the subsequent Commission inspection programme.

A first investigation of Omani hygiene standards was made in a 1998 visit of EU inspectors. Since this inspection by the EU officials, several improvements have been put in place both by the industry and the concerned authorities, including updating the QCA-97 for fishery export. These improvements also led to the lifting, of the ban on export of fish products to the EU by the end of 1998.

3.4. Conclusion

The situation of food safety policy prior to 1991

National policy of food control: National systems of food control were developed over a period of time and generally more than one ministry or department was involved in this activity (e.g., Oman). In some cases, a number of laws and regulations were issued without appropriate coordination of the different agencies. As a result, in many countries several agencies claimed the right to undertake fish inspection and quality assurance (for example, MAF, Muscat Municipality and Ministry of Regional Municipalities and Environment (Oman)). Many countries have now overcome this problem and inspection services are concentrated in one place, manned by knowledgeable people.

Legislation: Historically most developing countries had established food laws controlling, to some extent, the conditions under which food may be processed, stored and sold. National agencies prepared standards and codes of practice for products, including those for fish and fishery products. However, these codes and standards became irrelevant because they ceased to be appropriate for global market conditions. Many countries have, therefore, needed to update and radically alter their food hygiene legislation.

Raw materials: this is one of the biggest quality control problems in many of the developing countries. The hygiene standards of fish handling by fishermen at the fish landing sites is often, even today, very poor, and this damages raw material quality. An important strategic question for the industry in many countries is the development of the means (incentives, penalties, rules, infrastructure) to improve quality at landing sites.

Inspection: Fish inspection services in many developing countries have inadequate resources of skilled manpower, although the evidence from the Commission (Appendix IX) suggests that considerable efforts have been put into improving this. Inspection agencies traditionally devoted their resources to laboratory analyses of end-products destined for export, licensing plants and issuing export certificates. Less has been done to improve the standards of handling and processing on board, in the landing sites, in the processing plants and on the quality of fishery products sold for domestic consumption, although, again, improvements are in evidence. Moreover, In many developing countries, only exported goods are subjected to some official control, while products for the domestic market are sold with very little or no control.

Laboratories: Commission inspectors have frequently been critical of laboratory facilities in developing countries (see Appendix IX). The analytical techniques are inadequate and little inter-laboratory comparison is undertaken.

Limited awareness quality assurance: In developing countries the awareness of the industry about preventive quality assurance is limited. Quality control used to be often carried out by end-product testing (Lima Dos Santos, 1996). Preventive quality assurance should be designed to minimise spoilage, avoid contamination and assure that production and processing are carried out under acceptable GMP - evidently still lacking in many developing country environments.

Private sector role: The industry has often been reluctant to invest in the improvement of fish handling on board and in the landing sites. For example, this might have been done by the provision of fish boxes and ice to the fishermen. This is evidently a problem of collective action which will probably demand a greater regulatory input to resolve.

The main challenges to achieving equivalency with EU Directive

The EU Council Directive 91/493/EEC of July 1991 stipulates that fish should be processed stored and transported under satisfactory conditions of hygiene. Article 6 of the Directive requires that Member States ensure that persons responsible for fish handling and processing take all necessary measures, so that, at all stages of production of fishery products, the obligations are complied with. This requires a shift from the traditional end-product inspection and certification to the implementation of a preventive HACCP-based quality assurance approach. This presents developing fish exporting nations with new challenges, to update regulations, organize inspection services, modernize landing facilities, provide training, inspection facilities and equipment, improve handling and upgrade processing facilities (see Appendices IX and X). Therefore, investment will be required in physical resources, like building and equipment, and in human resources, like management and technological skills. The areas concerned with fishing vessels, fish landing sites, fish markets and transport should also be covered.

Inspection: The EU Directive requires that the inspection and monitoring of establishments be carried out regularly under the responsibility of the competent authority, which should have free access to all parts of the establishment, in order to ensure compliance. In the event that such inspections and monitoring reveal that the requirements of the Directive are not being met, the competent authority should act. Therefore, inspection should be carried out at all stages of industry production. These inspection programmes should focus on the hygiene, sanitation and environmental conditions at critical points and stages in the handling chain where fish contamination is likely take place.

Laboratory facilities: It is expected that each fish factory should operate a well-equipped and managed laboratory which should regularly carry out all sources of hazards. The same laboratory should also monitor water quality and workers' hygiene. The water used for washing, rinsing or conveying fish, or for ice manufacture should be safe and of adequate sanitary quality in accordance to the EU Council Directive 80/778/EEC.

Storage and transport: during storage and transportation, fishery products must be kept at temperatures laid down by the regulations i.e., frozen products at -18° C and chilled products at 0° C. Vehicles used for transport of fishery products should be constructed and equipped in such a way that the temperatures laid down in the regulations are adhered to and maintained throughout the period of transportation. If ice is used to chill the products, adequate drainage should be provided in order to ensure that water from melted ice does not stay in contact with products. Containers used for dispatch or storage of fresh fish or processed fish products must be designed in such a way as to ensure both their protection from contamination and preservation and storage under sufficiently hygienic conditions, and they should have free drainage of melt water.

Raw materials: all raw materials should undergo quality inspections, including organoleptic and visual checks, and their temperature should be low (4°C or less).

Impact on Developing Countries

There are two type of impact on developing countries, positive and negative.

Negative aspects

Compliance with the EU norms significantly increases the cost of production entry into the EU markets, but does not result in price premiums in the EU market. Consequence, the EU's restrictions have had a significant impact on fish processors, both in terms of the economic performance of individual companies and in the manner in which the sector as a whole is organized. Processors have had to invest significantly to upgrade their processing facilities and to improve their procedures so as to meet the EU's hygiene requirements. The improvements required to obtain approval for export to the EU, include upgrading of buildings and/or equipment, improvements to laboratory facilities, implementing HACCP plans, training of staff.

Positive aspects

The harmonization of national legislations of EU countries by means of a single Directive is a unique step in the field of upgrading inspection and quality control of fishery products not only within the Community but in the developing countries generally, which resulted positively in facilitation international trade of fish and fishery products from developing countries (i.e., avoiding the systematic detention, heavy sampling and laboratory checks at the point of entry in the Community).

Despite the hardship caused EU ban on exporters, there have been some positive developments in the industry These involve the introduction of legislative changes, reform of procedures for the approval for exports of fish to the EU and the issue of health certificates. Regulations were introduced to ensure hygienic fish handling and processing, in order to assure the safety of fishery products. This standard harmonizes hygiene requirements for fish with those of the EU.

Most of the developing countries examined by this study are reported to have strengthened existing national fish inspection and quality control structures at all level (fishing vessels, landing sites, processing plants, markets, government inspection structures, quality control at plant and laboratory levels have been upgraded) (FAO, 1999). Education and training initiatives in fish technology, inspection and quality assurance at all levels of the government and private sector are flourishing in many developing countries, again in close collaboration with industry, fish inspection and quality control services, training institutions and private quality control companies. The prize is maintaining access to the European and US markets, the possibility of achieving better prices and different markets through better quality and safer products (Caswell and Hooker, 1996).

Much was already been done. More is needed to improve fish handling on board and in landing sites, especially for artisanal fisheries, to train workers efficiently in personnel hygiene and sanitation, to train fish inspectors and industry people in HACCP, fish technology and preventive quality assurance, to develop inspection programmes appropriate to fit both for domestic and for export markets. This requires collaborative efforts from both official agencies and the industry to develop a working relationship whereby industry is responsible for carrying out the quality control and the government for ensuring that the industry is doing it properly.

Chapter Four

Evaluation of Fish Quality Control System in the Sultanate of Oman

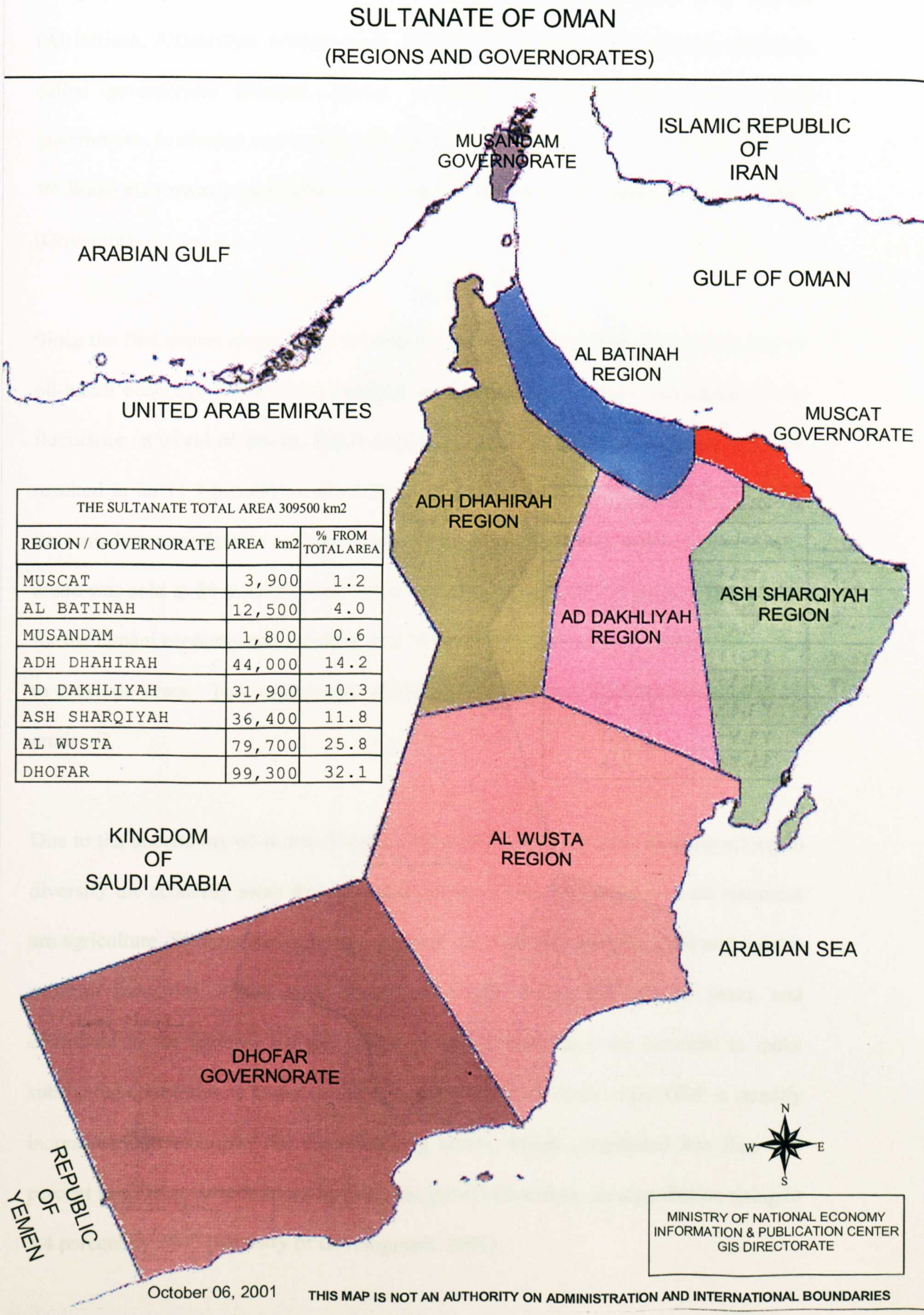
4.1. Introduction

The aim of this chapter is to emphasize the major fish safety problems, with special attention to product quality. The last section is concerned with the factors hindering application of a fish safety control policy in Oman. The food safety issue is considered within the context of the Omani economy and its fisheries sector.

4.2. Country profile

The Sultanate of Oman (Fig. 4.1) forms the south-eastern part of the Arabian Peninsula. Oman, with its 309,500 square kilometres of very varied, striking terrain and its two million inhabitants, is the second largest state by population (after Saudi Arabia) in the Arabian Peninsula. Its geographical location on the map lies between latitudes 16° 40' and 26° 20' north and longitudes 51° 50' and 59° 40' east. The country is bounded to the south by the Republic of Yemen; to the west by Saudi Arabia and the United Arab Emirates; to the north by the Strait of Hormuz; and to the east by the Arabian Sea. The coast stretches a distance of 1,700 kilometres, from Ras Musandam, on the southern side of the Strait of Hormuz in the north, to the Batinah, a plain inclining south-east towards Muscat, through the A'Sharquiyah region, to the near-tropical Salalah region in the south near the Republic of Yemen.

With its subtropical location, Oman's rainfall is relatively low and irregular with the exception of the southern region, where heavy rains occur during the monsoon season (June-September). The climate varies across the regions. In the coastal areas it is hot and humid in summer (May-September), but pleasant in winter (October-April). In the interior, it is hot and dry during summer, although it is temperate all year around in some higher altitudes, such as the Jabal al-akhdar plateau which is 3,075 metres above sea level.



THE SULTANATE TOTAL AREA 309500 km2		
REGION / GOVERNORATE	AREA km2	% FROM TOTAL AREA
MUSCAT	3,900	1.2
AL BATINAH	12,500	4.0
MUSANDAM	1,800	0.6
ADH DHAHIRAH	44,000	14.2
AD DAKHLIYAH	31,900	10.3
ASH SHARQIYAH	36,400	11.8
AL WUSTA	79,700	25.8
DHOFAR	99,300	32.1

Fig.4.1. Sultanate of Oman.

Geographically, the country is divided into five administrative divisions called regions (Al-Batinah, A'Dakhliya, A'Sharquiyah, A'Dahira, Al-Wusta) and three other divisions called governorates (Muscat, Dhofar, Musandam). Each of these regions and governorates is divided into smaller administrative divisions called Walayat. There are 59 Walayats (towns), each administered by Government representative called a Wali (Governor).

Since the first export shipment of oil from the country in late 1960s, Oman has had an oil-based economy (70% of the national income), and is strongly influenced by the fluctuation in world oil prices. The major violent slump in oil prices witnessed in 1986 resulted in an 11.3 percent devaluation of the Omani Rial. Although world oil prices have made a considerable recovery since then, during the last quarter of 1998 Omani crude was sold at $9 a barrel, well below the $18 which would be a comfortable price for the Omani economy and resulting in a 50 percent reduction in oil revenue compared to previous years. The performance of the economy is very sensitive to the price of crude oil.

Due to the uncertainty of world oil prices, the Government has been exerting efforts to diversify the economy away from its dependence on oil.. The major non-oil resources are agriculture, fisheries and minerals. To these can be added tourism, trade and light to medium industries, which have developed rapidly during the last 20 years, and contribute to the national income. These non-oil sectors have the potential to make substantial contributions to the national economy and their share of the GDP is steadily increasing. For example, the manufacturing sector, which contributed less than one percent to GDP at current prices in 1980, has grown since then, its contribution rising to 5.4 percent by 2000 (Ministry of Development, 2001).

4.3. Marine environment

The Omani sea is comprised of two different marine environments: (1) The Gulf of Oman stretches from the Strait of Hormuz in the northwest to the south-eastern tip of the Al-Hadd. It is characterized by sandy beaches northwest of Muscat and a mainly rocky coast between Muscat and Sur towards the southeast. The latter shows quite a steep bathymetry down to depths of more than 2000 m, and hence almost no shelf (5 nautical miles (Nm) at best), whereas along the northeastern areas of the Iranian coast, the shelf is well developed, but it is quite narrow (15-25 Nm) (Stirn, 1994). The coastal areas on both sides of the Gulf of Oman are rich in small pelagic, large pelagic, and demersal fish. (2) The Arabian Sea environment extends from the southern entrance of the Gulf of Oman to the Yemeni border, facing the open Arabian Sea with sandy beaches amounting to nearly two-thirds of the coastal zone, while the rest is rocky coast. The coastal area is rich in fish resources including small crustaceans (e.g., shrimp), small pelagic (e.g., sardine) and large pelagic fish (e.g., kingfish and yellowfin tuna) as well as a variety of demersal fishes, as reported by Stirn (1994).

The southern coast of Oman and other regions of the Gulf of Oman are subjected to two seasonal monsoons: the South West (SW) monsoon, which lasts from May to September and is the most severe, and the milder North East (NE) monsoon from November to March. In general, the winds that blow over the Arabian Sea are predominantly north-easterly, whereas they are more variable over the Gulf of Oman, but tend to have a large northerly component. In the Gulf of Oman, the wind speed is considerably lower than that in the Arabian Sea (Ministry of Agriculture and Fisheries, 1995).

The entire Arabian area, including the coast of Oman, is tropical with strong heating from solar radiation and high evaporation. This results in a high temperature and salinity in the surface layer. There is a bimodal temperature cycle throughout most of the year, with high water temperature (26-30°C) in April-May and in October. The drop in temperature in the summer (22-23°C) probably results from the intensity of the SW monsoon winds. Vertical water temperature profiles in the Arabian Sea show a strong decrease down to about 200 m. Temperature declines of up to 15-18 °C have been recorded from the surface to 200 m depth as reported by Kesteven et al. (1981).

There is a distinct difference between the circulation in the Gulf of Oman and the Arabian Sea with a sharp cut-off at Ra's Al-Hadd. The circulation in the Gulf of Oman, north of Ra's Al-Hadd, is much weaker and more variable than that in the Arabian Sea, and it has been suggested that currents here are governed to some extent by large scale eddies in the eastern Gulf of Oman (Quraishee, 1984; Edwards, 1984). It is probable that outflow from the Arabian Gulf also influences the circulation in the Gulf of Oman.

Additionally, the circulation in the Arabian Sea is characterized by a seasonally changing monsoon gyre. During the NE monsoon, an anti-clockwise current system is set up with currents running approximately southwest down the southeast coast of Oman. During the SW monsoon, a clockwise current system becomes strongly established. The circulation is intensified because of stronger winds (Quraishee, 1984). Currents run persistently northeast along the southeast coast of Oman. The current has a large offshore component, which creates a divergence in the coastal zone resulting in the well-known up-welling phenomenon between Salalah and Ra's Al-Hadd. The coastal strip affected is of the order of 100 to 400 km wide (Smith and Bottero, 1977; Edwards, 1984). Indeed, the SW monsoon plays an important role in generating upwelling not only on the southern coast of Oman, but also on the coasts of Somalia and Yemen during April-June.

General oceanographic conditions that were measured during the 1975-1976 survey by the R.V. Fridjoft Nansen have been summarized by Sandven (1979, p. 21) as follows:

> *The water structure in the Arabian Sea is characterized by a well mixed surface layer, which is separated from the subsurface waters by a highly stable boundary layer. This can easily be identified in the temperature, density, and oxygen profiles, and less pronounced in the salinity profiles. The position and strength of the boundary layer have marked seasonal and geographical variations. It is relatively weak in the northern area of the Arabian Sea during the NE monsoon. During the SW monsoon, the boundary layer rises and increases in strength in the whole Arabian Sea, except near the equator where it remains at about 100 m depth throughout the year. The surface layer throughout the year is characterized by warm, high saline water with oxygen content above saturation values, while the subsurface water is cooler, lower in salinity and has extremely low oxygen content, below 0.5 ml/L.*

4.4. Fisheries sector

Oman is one of the most important countries engaged in fishing in the Middle East. The 1,700 km coastline, with a commercial fishing area of 350,000 km^2, has rich fishing grounds, the potential of which has yet to be fully evaluated. A 200 nautical mile exclusive economic zone, extending out toward the sea from the baseline from which the territorial waters are determined, has been declared. There are 930 fish species available in the Omani waters, including 52 inshore species, of which four required new generic names (Randolph, 1995; cited in Sultan, 1996).

Fishing and agriculture have been traditional Omani occupations and sources of food and employment for the people in Oman. Before the discovery of oil in the country, agriculture and fisheries dominated the Omani economy, with around 80 percent of the population depending on these two sectors. Although the structure of the Omani economy has changed since the discovery of oil in the late 1960s, and agriculture has lost its position as the main contributor to GDP, agriculture and fisheries at present remain significant, if not large, contributors to the national economy. It is estimated that at present around 50 percent of the population in Oman still depend on these sectors (Ministry of Development, 2001). The development of these sectors has the potential to increase GDP under the government strategy to diversify the national economy. Besides their contribution to GDP, the development of these sectors has secured a continuous supply of food and will eventually decrease the dependency on other food-producing nations.

The potential of the agriculture and fisheries sectors has attracted the attention of the Government, whose investment in these sectors has steadily increased. Government investment in both sectors showed an average growth rate of 13.5 percent per year during the period 1971-1995, although this rate was reduced during the Fourth Five-year Plan (1991-1995) to an average of 1.5 percent per year and further reduced to 1% during the Fifth Five-year Plan (1996-2000) (Ministry of Development, 2001). Government investment in these sectors has contributed to a noticeable growth in both of them; the average growth rate achieved during the period 1996-2000 was 2.5 percent per year.

The agriculture sector's share of the gross national product was 1.3 percent in 2000, and is predicted to rise to 3.1 percent by 2020 (Ministry of Development, 2001). Government planning for the Omani economy places major emphasis on the fisheries sector. The sector is expected to grow, somewhat optimistically, at an annual average rate of 5.6 percent by the year 2020. It is hoped that the fisheries sector will contribute around 2 percent to the gross national product in 2020 compared to its level of 0.6 percent recorded in 2000 (Ministry of Development, 2001). Food safety's contribution to this ambition is through adding value to the product of the industry.

There is a strong fishing tradition in Oman, and a large number of small villages scattered along the coast, from which around 28,500 small-scale fishermen operated in 2000 (Ministry of Agriculture and Fisheries, 2001).

With the advent of a petroleum-based economy, Oman underwent rapid social and economic changes. Young men drifted away from fishing communities to the cities where they could earn better wages. This led to a shortage in manpower skills in the traditional occupations. The Government has recognised the effects of its development programmes on traditional occupations and steps have been taken to stem this drift by initiating programmes to develop the traditional fishing sector and help the people to continue with their fishing occupation. With such encouragement, there has been an increase in the number of fishermen, suggesting interest in fishing as an occupation. The situation has now stabilised with 28,576 fishermen directly employed in the fisheries sector in 2000 compared to only 11,750 recorded in 1985 (Ministry of Agriculture and Fisheries, 2001). The increase in the number of fishermen is attributed mainly to the introduction in 1978 of the Fishermen's Encouragement Fund, which induced coastal inhabitants to keep to their traditional occupation. The Fund provides financial assistance for the purchase of fibreglass fishing boats, engines and fishing gear. The Agriculture and Fisheries Bank administered the Government's subsidy programme with an aim of upgrading the fishermen's socio-economic conditions and making the fisheries profession attractive. For example, during 1980-2000 the banks processed subsidised loans to small-scale fishermen with a total value of RO 10.541 million ($ 27.71 million[1]) at an interest rate of two percent (Ministry of Development, 2001).

The fisheries of Oman are divided into traditional and commercial fisheries. For example, in 2000 the traditional fishery contributed around 90 percent of the total national landings, the balance being produced by the commercial sector, which is composed of foreign-owned demersal trawlers and longliners (Ministry of Agriculture and Fisheries, 2001). The traditional fishing fleet has been enhanced by increasing the number of units to 13,248 in 2000, and replacing the older vessels. By 1993, almost all the traditional fishing fleet had been mechanised by means of the Fishermen's Encouragement Fund. The total Government expenditure during the period 1978-1992 to subsidise the traditional fishermen reached RO 6 million, used to help around 16,162 fishermen. During the same period, around 8,462 fibreglass fishing skiffs and 14,106

[1] A rate of RO 0.384 to US $ 1 has been used as a rate of exchange in this study.

engines were subsidised, while the expenditure decreased during the period 1996-2000 to OR 104,200, used to help around 204 fishermen (Ministry of Development, 2001).

4.4.1. Fishing fleets and gears

The fisheries in the Sultanate of Oman can be classified into traditional and industrial sectors based on the technological input to the fishery. The earliest information on Omani fisheries came from the 1978 and 1984 surveys of socio-economic aspects of the Omani fishing communities (Pollnac et al., 1984). The purpose of the surveys was to provide a description of various aspects of the harvesting sector and to give a brief description of fishing communities, vessel types, gear types, and fishing techniques involved in the fisheries.

In the late 70s, there was considerable diversification of vessel types including, *houri, sambuk, sasha, shahouf,* launch, dhow, aluminum boat, *alamla, betal*, and fibreglass boats. At that time, the use of fibreglass vessels was almost nonexistent, and 68% of the vessels in use were *houris* or small wooden boats. The large vessels were between 40 and 50 feet with only a few measuring up to 60 feet in length. Launches (10 m or longer) were considered to be intermediate in size, between the houri and the dhow. A few boats used sail, but 35% of the boats surveyed were relying on oars rather than engines.

Several types of fishing gear were used by fishermen, but the majority of the catches were landed by drift gill nets, hand lines, pen nets, traps, beach seines, and cast nets. The gear type depended on the type of fish (pelagic or demersal); the most common gear involved in the large pelagic fishery was the drift gill net (Pollnac et al., 1984).

By 1984, a considerable change had occurred in the traditional fishing fleet. There were vast increases in the number of fibreglass vessels (6 - 10 m) and outboard motors, attributed to the Fishermen's Encouragement Fund provided by the Government. A survey in 1995 at various fish landing centres along the Omani coast have shown that fibreglass boats often constitute from 70% to over 90% of the boats being used for fishing (Ministry of Agriculture and Fisheries, 1995).

Traditional fishing is carried out at night and the catch landed in the following morning. Most of the fish are caught with drift (unanchored) gill nets, which extend from 1000 to 2000 m in length. The nets are hung from the surface of the water and extend up to 10 m or more down into the waters. Often, one end of the net remains attached to the vessel by a rope. The most commonly used stretch mesh sizes are 4.25 inches for adult fish and 3 inches for juveniles.

Fish are also caught by troll lines, hand lines, pen nets, and traps (especially along Oman's northern coast). However, drift gill nets are the most efficient gear and used for capturing fish of any size. The baited lines are size selective. Some fishermen use them while setting drift gill nets (Ministry of Agriculture and Fisheries, 1994).

The industrial fishery refers to large fishing vessels that either operates trawl nets targeting demersal species or use long-lines to catch large pelagics on the high seas. The involvement of foreign fleets in the Omani fishery first started in 1976 when the Ministry of Agriculture and Fisheries entered into a contract with a Japanese fishing company and later on with a Korean company in 1978, allowing these companies to operate in the Omani waters against a percentage of the catch.

In 1989 the Government decided to give five private Omani companies a production quota. The Oman Fisheries Company is a leading commercial company which was established in 1989. Twenty-four percent of its equity is owned by the Government and the rest is held by thousands of shareholders. Oman Fisheries Company, like other local fishing companies, does not fish on its own account but contracts demersal fishing rights to Korean and, lately, to Chinese trawl operators and large pelagic fishing rights to the Taiwanese. The number of foreign vessels licensed by Omani private companies since 1989 has varied, as has the sharing system employed in exchange for fishing authorisation.

The number of foreign fishing vessels varied between 1989 and 2000. There were 9 trawlers operating in Omani waters during 1990 to 1992. The number increased gradually to 25 in 1994 and then dropped to 19 in 1995. The number of trawlers fishing in Omani waters in 2000 was 21. Similarly, the number of longliners varies according the availability of the large pelagics; there were 135 in 1994, 74 in 1995 and 96 in 2000 (Ministry of Agriculture and Fisheries, 2001).

To protect the traditional fishermen's fishing grounds, foreign fishing vessels are required to operate at more than 10 nautical miles from the coastline or 50 metres depth, whichever is farther, in the case of the trawlers and about 20 nautical miles in the case of the longliners. Despite the Ministry's effort to monitor the activities of the foreign fishing fleets, a lot of criticism is directed towards their activities in Omani waters. As stated by Sultan (1996) "*there is a gross under-reporting of the catch to the authorities and the possibility of off-loading on the high seas is often mentioned*". Intrusion into the rich fishing grounds of the traditional fishermen can be added to the above criticisms, as confirmed by regular conflicts with traditional fishermen and court suits over various disputes, which reached 541 between 1990 and 1995 (Sultan, 1996).

4.4.2. Fish landings

Although the traditional fishery is still predominantly small-scale, it constitutes the most important sub-sector, accounting for about 86 percent of the total fish landings in 1985. There do not appear to be any statistics available relating to fish landings in the early 70s but Table 4.1 shows the annual fish landing between 1985 and 2000. Two distinct peaks can be noticed from Table 4.1. The total quantity of fish landed rose sharply through the 1980s, peaking first in 1988 when landings rose from 94,900 metric tonnes in 1985 to 166,100 metric tonnes in 1988. This sharp increase in fish landings is attributable to technological development as a result of the fisheries development programme initiated by the Government to upgrade the sector. For several years following that peak, catches decreased (Figure 4.2). Total landings hit a low of 112,300 metric tonnes in 1992 but then generally increased. This was considered as the first sign of overfishing which was caused by excessive pressure on the coastal fisheries resulting from the development programme during the 1980s (Siddeek, 1995; Sultan, 1996).

Table 4.1. Total fish landings (metric tonnes) and value (RO million) between 1985 and 2000.

Years/Sector	Traditional		Industrial		Total	
	Landing	Value	Landing	Value	Landing	Value
1985	81525	22.34	13368	2.7	94893	25.04
1986	82776	21.83	13561	2.73	96337	24.56
1987	124133	30.52	10956	2.46	135089	32.98
1988	148168	27.25	17911	6.7	166100	33.95
1989	105247	27.73	12290	5.7	117537	33.43
1990	99798	27.12	18843	7.5	118641	34.62
1991	103536	22.26	14229	6.09	117765	28.35
1992	97046	26.01	15267	6.61	112300	32.62
1993	92434	24.39	24035	9.91	116469	34.3
1994	97535	28.67	21037	9.7	118572	38.37
1995	108566	47.25	31295	13.62	139861	60.87
1996	88514	39.85	33101	13.97	121615	53.82
1997	84444	45.24	34549	14.17	118993	59.41
1998	88557	46.66	17608	7.76	106165	54.42
1999	96664	49.15	12145	6.37	108809	55.52
2000	108000	46.57	12401	6.20	120000	52.77

Source: Ministry of Agriculture and Fisheries. 2001. Annual statistics report.

However, total fish landings started to increase gradually after 1992, reaching a second peak in 1995, at about 139,861 tonnes, but again declined subsequently (Figure 4.2). The total fish landings in 1996 were 122,615 metric tonnes, 14 percent lower than those recorded in 1995. In the following year (1997) another 2.5 percent reduction in fish landings was recorded, while an 11 percent reduction was recorded in 1998. In 2000, a 9.0 percent increase compared with 1999 was noticed (Ministry of Agriculture and Fisheries. 2001). The average fish landing during the period 1985 to 2000 amounted to 111,800 metric tonnes.

In 2000, the total fish landings in Oman were 120,000 metric tonnes, representing a small increase of 11,191 tonnes compared to the landings of 1999. Out of the total fish landings, the traditional fishermen produced 108,000 tonnes of fish, representing 90 percent of the total fish landings, which was 11,336 tonnes more than those landed in 1999. The value of fish landings decrease, reaching RO 52.77 million in 2000 compared to RO 55.5 million in 1999 (Table 4.1).

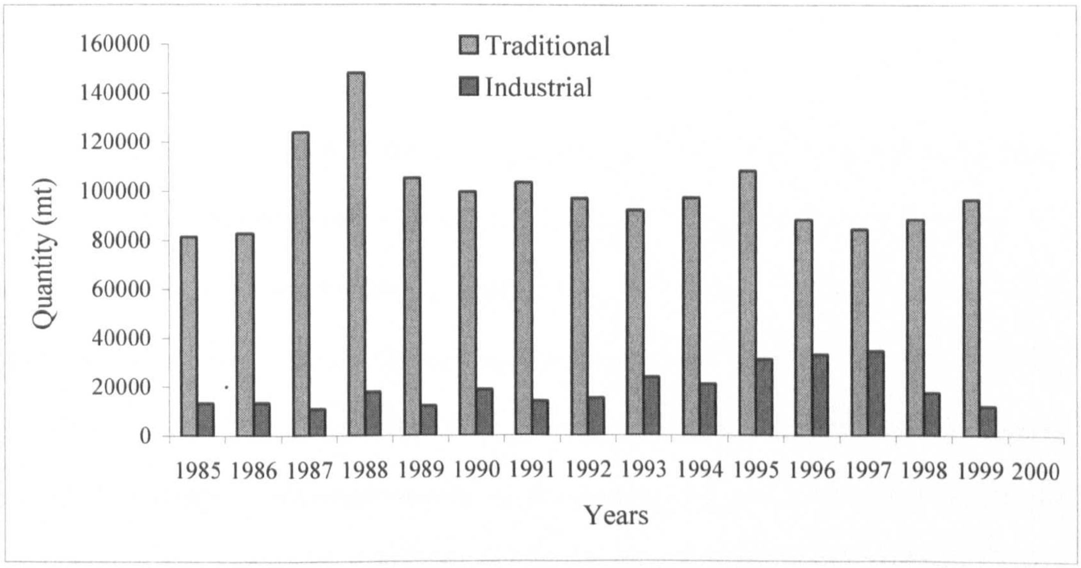


Fig. 4.2. Fish landings trends in the Sultanate of Oman, 1985 – 2000.

Source: Ministry of Agriculture and Fisheries. 2001. Annual statistics report.

It is reasonable to relate the increasing trend in total landings during the 1980s to the progressive expansion of the number and type of fishing vessels. The initial impetus for the expansion of the traditional fishing fleet occurred in 1978 when the government launched the Fishermen's Encouragement Fund. The fund provides financial assistance for the acquisition of fibreglass fishing vessels and engines to replace the native wooden fishing vessels. Statistical figures available for 1985 onwards suggested that the number of fishing vessels (the vast majority of which were motorised fibreglass skiffs) increased by 28 percent from about 9,000 vessels in 1985 to 13,248 vessels in 2000.

Regarding the number of fishermen, this has increased from 11,750 in 1985 to 28,576 in 2000, an increase of 59 percent. The increase in the number of fishermen can be attributed to the government programme to encourage local people to stick to their occupation and to the shortage of alternative employment opportunities facing the country since the early 1990s with the fall in oil prices.

Despite the declining trend of the total fish landings, as well as the traditional ones, figures for the value of landed fish follow an increasing trend, as shown in Figure 4.3. As can be observed from Figure 4.3, from 1993 onward, the values of the landed fish continued to increase, but at a higher rate. The value of the landed fish in 1987 was RO 33 million, and had jumped to RO 52.77 million by 2000. This increase in the value of the total landings is ascribed mainly to the increase in the value of the landings produced by the traditional fishermen, which reached its highest level during the last five years, as shown in Figure 4.3. The value of the catch landed by traditional fishermen follows a similar trend to the total; it witnessed a sharp increase after 1993, despite the declining trend in the quantity landed. The value of landings produced by the traditional fishermen represented 99 percent of the total value landed in 2000.

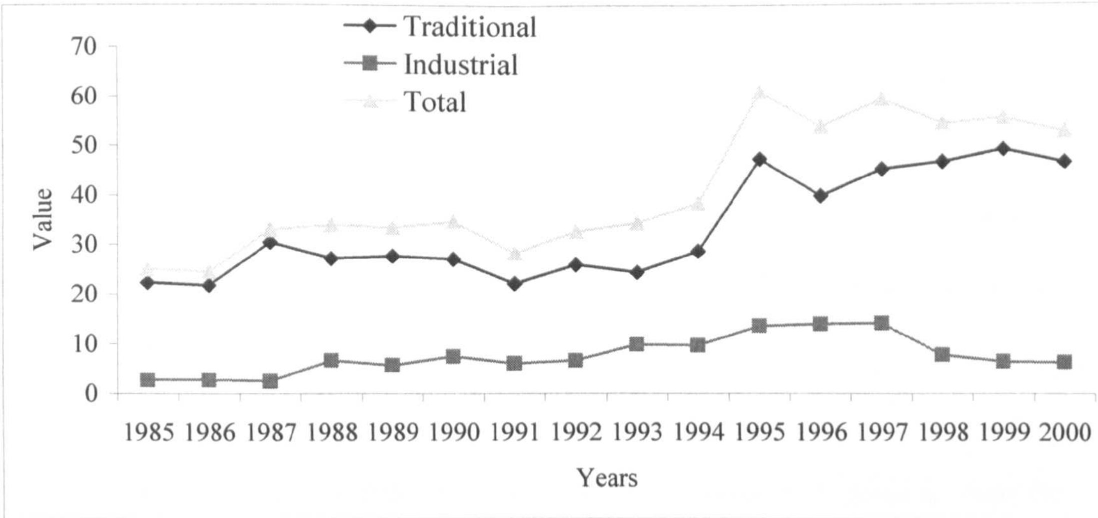


Fig. 4.3. Value of the fish landings in RO Million during 1985-2000.

Source: Ministry of Agriculture and Fisheries. 2001. Annual statistics report.

Although fish landings declined for several years, this improvement in the value of the landed catch can be related to the improvement in the quality of the landings and reduction of waste due to bad handling and storage. This can be ascribed to the newly built landing facilities and cold storage constructed by the Government. During the Fourth Five-year Plan (1991-1995), the government planned to build eight large fishing ports and 16 smaller ones along the coast to provide landing facilities in order to improve fish handling and to create fishing based industry around these facilities. In 1994, the government allocated RO 40 million ($104 million) to build 12 fishing ports, eight of which are currently in operation.

The value of the landings produced by the commercial sector, has increased and then decreased for the last three years (Figure 4.3). In 2000, the value of the catch landed by the commercial sector reached RO 6.2 million, making a decrease of RO 6.4 million compared to the corresponding figure for 1999. During the last fourteen years, the value of the landings of the commercial sector has increased from about RO 2.7 million in

1985 and 1986 to RO 14.2 million in 1997, and then decreased to 6.4 in 1999 making, an decrease of RO 6.2 million. The percentage contribution of the commercial sector to the total value of the landings was 12 percent in 1999, as compared to 14 percent in 1985. The increase in the value and landings of the commercial sector can be related to the rapid expansion of the commercial fishing fleet in the Omani waters, especially during the 1990s.

As indicated above, the total fish landings in Oman are made up of landings from the traditional and the commercial sectors. The traditional fishery plays a significant role in the Omani fishery. However, as indicated in Figure 4.2, the landings of the traditional fishery have shown a declining trend for several years since the late 1980s. For example, during the period of 1985 to 1992, the average percentage contribution of the traditional fishery to the total landings was about 88 percent. However, for several years following 1992, this share was on the decrease; the average percentage contribution declined to 81 percent during the period 1993 to 2000 (Figure 4.4).

The contribution of the traditional fishery to the total landings was 90 percent in 2000. Despite the slight increase in 1998 and 1999, which might be due to environmental improvement, such as availability of food and good water temperature, it is reasonable to assume that the declining trend in the landings of the traditional fishermen during the last eight years may be correlated with the progressive expansion in the number of fishing vessels and fishermen. It is interesting to see that fishing effort has been on the increase during the same period. Therefore, this gradual decline in the catch of the traditional fishermen can be largely attributed to overfishing in inshore waters.

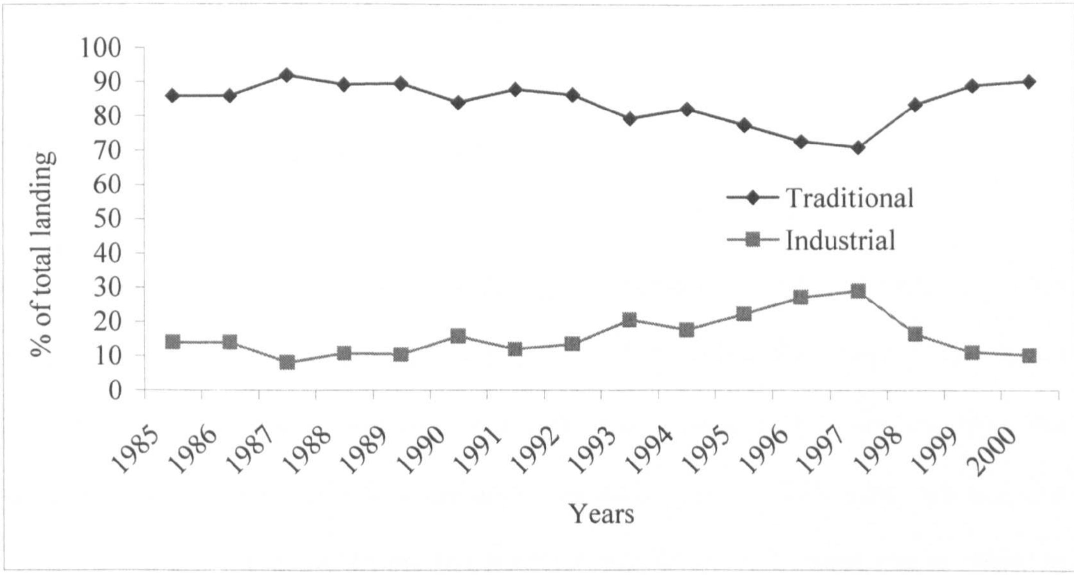


Fig. 4.4. Percentage share of the traditional and the commercial catch of the total landings during 1985-2000.

Source: Ministry of Agriculture and Fisheries. 2001. Annual statistics report.

In contrast to the traditional sector, the landings of the commercial sector increased, up to 1997 and then declined gradually (Figure 4.4). The average percentage contribution of the commercial sector to the total landings rose from less than 10 percent before 1987 to around 30 percent in 1997. In 2000 the average percentage contribution of the commercial sector to the total landings declined to 10 percent. The percentage of the catch retained by local companies, for example, has varied from 39 percent in 1988 to its current level of 20 percent. Foreign fleet operators consider such long-term fishing businesses to be profitable, as evidenced by the long period of the contract.

4.5. The economic significance of the fisheries sector

4.5.1. Contribution to the national GDP

The fisheries sector's contribution to the Gross Domestic Product (GDP) in market prices enjoyed modest growth in the period 1980-1994, with a sharp increase in 1987 in which the GDP was 68 percent above the 1980 level (Table 4.2). Following 1987, the sector witnessed modest growth again until it peaked again in 1995. That year was one of significant growth, in which the sector's GDP was 69 percent above that recorded in the previous year, and 209 percent above the 1980 level (Ministry of Development. 2001).

Although the sector's GDP contribution fluctuated around 1.0 percent, there have been some sharp reversals. For example, the GDP in 1988 was 10.6 percent below the 1987 level and another fall was recorded in 1991 when the sector's GDP was 21 percent below the 1990 level. In 2001, the sector's GDP was RO 56 million, 11 percent above the 1999 level (Table 4.2). During the period 1980 to 2000, the relative contribution of the fisheries sector to the non-oil GDP at current prices ranged from 0.85 percent to 1.92 percent, averaging 1.3 percent. As a proportion of the total GDP, the sector's GDP during the same period accounted for between 0.5 percent to 1.0 percent, with average of 0.7 percent. The fisheries sector is expected to contribute around 2 percent to the gross national product in 2020 compared to its level of 0.7 percent recorded in 2000 (Ministry of Development, 2001).

Table. 4.2. Key indicators of the fisheries sector, 1980-2000.

Year	Sector GDP (million)[2]	ANNUAL GROWTH (%)	GDP share (%)	Share of non-oil GDP (%)
1980	16.9	-	0.8	1.92
1981	19.7	16.57	0.7	1.76
1982	21.0	6.60	0.8	1.62
1983	24.8	18.10	0.8	1.68
1984	24.1	-2.82	0.7	1.42
1985	22.1	-8.30	0.6	1.21
1986	21.6	-2.26	0.7	1.12
1987	28.3	31.02	0.9	1.54
1988	25.3	-10.60	0.8	1.26
1989	27.3	7.91	0.8	1.30
1990	28.1	2.93	0.6	1.17
1991	22.1	-21.35	0.5	0.85
1992	26.7	20.81	0.6	0.93
1993	26.9	0.75	0.6	0.88
1994	30.9	14.87	0.6	0.96
1995	52.2	68.93	1.0	1.55
1996	46.2	-11.10	0.8	1.30
1997	52.8	13.90	0.9	1.40
1998	50.9	-3.60	0.9	1.30
1999	52.3	2.70	0.9	1.40
2000	48.7	-7.0	0.6	1.20
Average	32.0	7.0	0.7	1.30

Source: Ministry of Development. 2001. Annual statistics report.

4.5.2. Contribution to foreign exchange earnings

In terms of foreign exchange earning, fish exports increased steadily between 1981 and 1988, and then fluctuated around RO 19 million between 1989 and 1994 (Figure 4.5). The year 1995 witnessed a significant increase in the value of fish exports, reaching RO 41.2 million, which was 46 percent above the 1994 level. The value of fish exports increased in 2000 to 23 percent above the 1999 level, as shown in Figure 4.5. Gradually, fish value increased after 1997. Fish export value increased in 1998 to 3.5 percent above the 1997 level. A further 21 percent increase in the value was recorded in 1999. Similarly, the quantity of fish exported increased steadily and peaked in 1995 when 59.2 thousand tonnes were exported, which was 33 percent above the 1994 level. After 1995, the quantity of fish exported declined. In 2000 it was 49 percent below the 1995 level (Figure 4.5).

The reduction in the quantity and value of fish exports was to be expected due to the declining trend in landings by the traditional sector during the same period. Restrictions imposed by the European Union on fish imports that do not comply with the Union standard are another factor which contributed to reduce the quantity and value of fish exported from the country. The improvement of the export quantity and its value was consequently due to the partial lifting of the EU ban in 1998. Fifteen seafood export-processing companies were certified to export to the EU since then, while others are still waiting.

Fish exports are considered to be a significant earner of foreign exchange to the national economy, ranking second after oil exports and first among the non-oil exports.

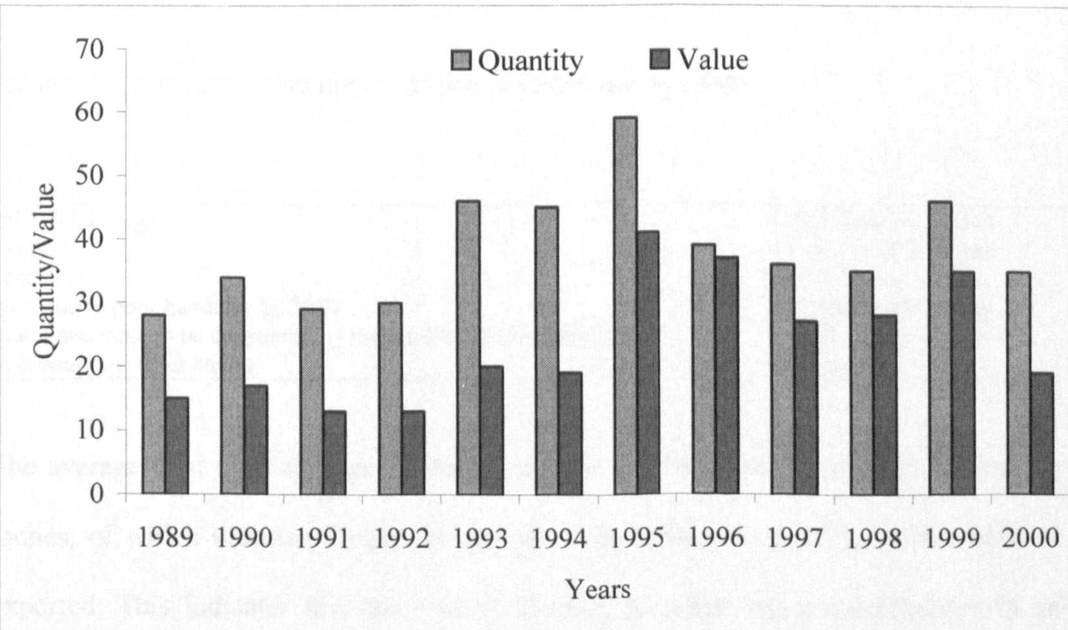


Fig 4.5. Fish Exports in Metric Tonnes (1000's) and Value in (RO million), 1989–2000.

[2] Current prices

Source: Ministry of Agriculture and Fisheries. 2001. Annual statistics report.

4.5.3. Contribution to food security

Fish has been an important staple food for the Omani coastal inhabitants for countless centuries, providing a large portion of their protein requirements. Fish is transported, chilled with ice or in refrigerated trucks, all over the country by an excellent network of national highways. As stated by Jenkinson (1987, p. 12) "*fish consumption per capita in Oman is high when compared with other nations in the Arab region*". According to the 1983 FAO Yearbook of Fisheries statistics, annual per capita fish consumption in Oman was 20.3 kg. Table 4.3 provides a rough estimate of the per capita fish consumption in Oman during 2000. As shown in Table 4.3, the per capita fish consumption is approximately 21 kg/year. The figure represents the quantity of fish available to each person in Oman during the 2000 after fish exports and losses due to poor handling were deducted and by employing a generic flesh yield coefficient of 70 percent.

Table 4.3. Apparent consumption of fish in Oman during 2000.

Total fish landings	120,000 metric tonnes
Exports	- 35,000 metric tonnes
Balance	85,000 metric tonnes
Losses due to poor handling @ 30 %	- 25,500 metric tonnes
Amount available to be consumed by the 2 millions total population	59,500 metric tonnes
Fish consumption per capita	21 kilos/ year

The average total fish landings in Oman between 1985 and 2000 were 111,800 metric tonnes, of which between 70 and 80 percent were consumed locally and the balance exported. This indicates that the country is close to achieving self-sufficiency in an important source of animal protein. However, if this is going to be achieved, current landings must be sustained or more efforts need to be directed to the exploitation of the off-shore fishery in order to increase fish landings to off-set the increased demand inside the country as the result of the high population growth rate, which was estimated at 3.5 percent in 1993 (Ministry of Ministry of Development, 1993).

4.5.4. Contribution to employment opportunities

The other significant role of the fisheries sector is its contribution to employment for the Omani people. The artisanal subsector is a reserved occupation for Omani nationals. The fisheries sector provides thousands of employment opportunities for Omani nationals, especially those inhabiting the coastal villages. The sector provided direct employment for 28,576 traditional fishermen in 2000. Another 5,000 people are engaged in fisheries-related activities, such as fish handling, selling, processing and distribution, as well as ancillary industries like workshop mechanics and selling of fishing gears and spare parts. Therefore, the fisheries sector provides direct employment for 32,516 Omani nationals, or 1.6 percent of the total population. More employment opportunities are to be created in the fisheries-based industry that is planned to be established around the fishing ports currently under construction. There would also be around 3,500 employment opportunities for the Omani people if the commercial fleet were to be fully Omanized. The fisheries sector is expected to employ around 50,000 fishermen in 2020, compared to its level of 28,576 fishermen recorded in 2000 (Ministry of Development, 2001).

4.6. Quality constraints on fish supply chain

Most food safety problems in developing countries are caused by improper food handling, especially during harvesting, handling, distribution, sale and preparation for consumption (FAO (1994b)).

In Oman, there is considerable economic waste because of poor quality fish. In handling fish on the vessel, in the market place, in the processing plant, and in distribution, lack of ice and insanitary handling result in an economic loss from a valuable economic resource. It is difficult to quantify the exact magnitude of this loss, but it is significant. Some processors estimate that 20-30 per cent or more of the fish they consider for purchase is of bad quality. Some knowledgeable people in the Directorate General of Fisheries (DGF) estimate that it could exceed 30 percent of the value of the landings. If this figure is correct, in 2000 the total economic loss from poor quality products in seafood could have easily exceeded RO 19 million.

Some officials in the Ministry of Regional Municipalities estimate that at least two percent of the fish in the fish markets is condemned because of poor quality. In some cases, landings of large quantities of valuable fish, such as tuna, have been observed with very little or no use of ice, resulting in spoilage of much of the catch. The market place is also responding to the poor image and quality of Omani fish products. Exporters reported that products exported from Oman do not have as good market as those from other countries and usually receive a lower price. The DGF in the Ministry of Agriculture and Fisheries estimates, for example, that the value of Omani lobster export is about one-half that of Australian exports of the same quantity a loss of RO 7 million.

If Oman is to secure and maintain markets abroad, and protect and preserve the quality image of its exported seafood products, Oman should modernise food safety policy based on quality assurance programmes as required by the major fish importing countries. It needs, therefore, to follow the implied advice in Council Directive 91/493/EEC, in the main text and in the various Chapters of the Annex. This Directive recognises the important of food safety and quality during the food supply chain and focuses on control during each stage of handling and processing, from catching to final sale. It is this control which ultimately determines the quality of the product reaching the consumer.

Following the fish supply chain in Oman, the researcher observed that there were five essential stages that hinder fish quality in Oman. These are (a) fish catching and handling, (b) use of ice by fishermen, (c) ice supply, (d) transportation and distribution of fish and (e) conditions in fish markets. Those components will be discussed in more detail below.

4.6.1. Fish catching and handling

Quality assurance on board fishing vessels is the first link in the quality fish chain that runs from the start of production to final consumption. Catching the fish can be regarded as the beginning of the problem. The condition of the fish coming on board depends on a number of factors, such as how long the fishing operation has taken, or the length of time a set net has been in the water. Once the fish has been brought on board, temperature control is all important; the higher the temperature, the more rapidly the fish spoil. Processors may claim that they have no control over the practices on a boat, and that is true up to a point; where they do have control is in what they buy. It soon becomes obvious from the condition of the fish, which boats are looking after their catches correctly.

Fishing by the traditional fleet may take several hours directly under the sun and temperatures can reach up to 40°C in summer. Exposure of fatty fish to sun, air and ambient temperature for a few hours (which may be considered as a CCP as defined in Chapter Two), is sufficient to introduce severe quality loss and cause early chemical spoilage. Growth of bacteria such as *C. botulinum, V. parahaemolyticus,* various *Vibrio* sp., *L. monocytogenes, Aeromonas* sp. can take place in such circumstances as reported by Hsing-Chen Chen (1995).

Some pathogenic bacteria are naturally present in the aquatic (*C. botulinum type* E, pathogenic *Vibrio* sp., *Aeromonas*) and the general environment (*C. botulinum* type A, B, *Listeria monocytogenes*) (see Chapter Two). These pathogens may therefore also be found on the live fish or fish raw material. The presence of these organisms is normally not a safety concern since they are present on the fish in numbers too low to cause disease (Huss, 1997). An exception is accumulation of high numbers of some of these organisms (*Vibrio* spp.) in filter-feeding molluscan shellfish, particularly since these animals are often eaten raw.

Capturing, handling, and transportation are responsible for a great release of adrenaline and cortisol in fish tissues, causing a shortening of time for the onset of rigor mortis, which softens fish texture and enhances the ease of penetration by pathogens (Reilly et al., 1997). Increase of microbial load is prevented by the gentle treatment of animals during transport, whilst a well-controlled cold chain keeps it that way (Sigholt et al., 1997). Fatty fish can be influenced to a great extent by chemical reactions and they can become unacceptable for consumption even when they remain in the freezer (Jorgensen, 1995). However, oxidation and hydrolysis of fat fish are accompanied at first by a severe odour and finally by the appearance of yellowish spots on fat tissues before the fish becomes unsafe for consumers, so a macroscopical evaluation of the fish may be useful (Hobbs, 1982).

In the case of Oman, where small boats are used, to prevent/minimize the growth of pathogenic bacteria or histamine[3] producing bacteria spoilage bacteria, the fish catch is officially required to be landed to the adjacent fish markets. The preventive measures in this case are time and temperature combination (t). At t < 1 °C, no growth of pathogenic bacteria takes place. Only small and insignificant amounts of histamine may be formed and bacterial spoilage is not inhibited, but takes place at a "normal" and expected rate. A maximum time at t >5°C (or maximum processing time) should be specified in the criteria or tolerances for this CCP.

Quality assurance on board a fishing vessel should begin by minimizing the risk of a quality defect causing a health risk to the consumer, as well as in the other requirements of the buyer. In the absence of defined procedures, quality assurance systems on board fishing vessels must be developed according to two European Council Directives (a) 91/493/EEC, to establish the health conditions for the production and placing on the market of fishery products, and (b) 92/48/EEC, laying down the minimum hygiene rules applicable to fishery products caught on board certain vessels in accordance with Article 3 of Directive 91/493/EEC (i.e., It includes rules concerning technical design and equipment on board and rules concerning hygienic handling and chilling on board) (see Appendix X).

4.6.2. Use of ice by fishermen

Large quantities of fish are landed spoiled because ice is not generally used for the smaller boats of 3 to 10 metres used by the traditional fisheries that stay out for longer than 4-6 hours, or for some of the larger *dhows*. Most of the smaller boats in the traditional fishery do not use ice. For those boats that stay out for 4 to 6 hours, ice may not be needed if the fish are covered and kept from the sun. Some fish, especially sardines, landed after being on the boat for 3 to 4 hours, are still alive when landed.

Those boats that stay out longer than 4-6 hours and do not use ice are the main problem. The small boats do have space for carrying ice, but the fishermen appear to have little incentive, under the present market system, to purchase ice at a cost of RO 20 per tonne. Also, ice is not usually available.

The larger traditional *dhows* are equipped with a box for carrying ice, but in a number of cases they do not carry it. It is not uncommon to find large catches of fish such as tuna or shark being brought in without ice, with much of the fish being spoiled. Ice is not readily available to many fishermen, and there are no regulations enforcing the use of ice by fishermen. On the other hand, consumers' attitudes play a significant role in ice use; they prefer the fish to be presented as it is (e.g., at the terminal state of its quality) rather than in ice, because ice increases the price. Moreover, consumers tend to believe that iced fish is not fresh fish.

[3] Histamine poisoning is often called scombroid fish poisoning. Scombroid fish, including tuna, mackerel, bonito, and butterfly kingfish, contain high levels of free histidine, which is readily decarboxylated to

4.6.3. Ice supply

The supply of ice is a problem for Oman. There are fewer than 30 ice plants along 1,700 km coastline producing ice available for use in production, processing, and transportation of fish. Most ice plants are operated by fish processing factories for their own purposes or to supply fishermen who are fishing for them. There are many areas along the coast where ice is not readily available to the fishermen or to those transporting fish in iceboxes. For example, one ice plant in a company at Sohar (more than 200 km from the Capital) produces 15 tonnes of ice per day. It is the only plant along the coast from Muttrah to Aswad, except for a small one at Seeb, which produces about five tonnes a day, and the ice is not always available to truckers and fishermen, because the processors use most of it. The distance involved also makes it impossible for many fishermen to use ice from this plant, even if it is available.

Lack of ice and insanitary handling results in losses to the sector. Possible solutions might be programmes to encourage fishermen to use ice on fishery boats and vessels by means of subsidy, training or regulation. A precondition would be the availability of ice in the required locations.

4.6.4. Transportation and distribution of fish

There is no regulatory system to quality-assure the transportation and distribution of fish. At present, fish landed by the fishermen go directly to the adjacent market, are trucked to a market, or are purchased by buyers who transport the product to a processing plant, out of the country, or to local inland markets. Fish destined for export

histamine by a great variety of bacteria (Mossell et al., 1999) appears to be cared for best, because it is usually transported in iceboxes, with ice, if available.

Fish destined for local inland markets may be transported in iceboxes or even in open trucks without any ice (visual evidence supplied in Appendix VI). Practices used for transporting fish from the vessel to the processing plant vary widely. In some cases, processors send a truck with ice to pick up the fish. In other cases the fish are just loaded into dirty trucks, kept in the hot sun for several hours, and then transported to the processing plant with no ice.

The transport vehicles currently in use increase the potential for food to be damaged during handling between fish landings and their destination. These vehicles' containers ideally should be constructed of fibreboard, fibreglass or laminates and they may be refrigerated for transporting fresh/frozen fish. The transportation of fish would then be consistent with the requirements of Council Directive 91/493/EEC (Chapters II and VIII of the Annex).

4.6.5. Conditions in fish markets

The next stage is the market. Often, losses due to exposure in the market are overlooked, but irreversible damage can occur to the fish if it is neglected at this stage. Ideally fish should be boxed, well iced and graded by size, species and quality. The period on the market should be kept to a minimum and fish should be sold and despatched as quickly as possible, conditions which are rarely achieved in Oman.

Fish markets in Oman are poorly designed and would not meet international standards; fish are not handled in accordance with hygienic principles. The researcher visited the main fish markets at Muttrah, Seeb, Sohar , Barka, Sur, and Salalah, all of which are of open construction (see Appendix VI). In many cases, wall partitions and floors are of tile, but there are no doors that could be closed to seal off the market, as is required by EU standards described Chapter IV of the Annex to Council Directive 91/493/EEC. Cross-contamination and growth of bacteria could occur. Therefore, fish markets could be considered as CCP in the fish supply chain. There are no separate fish cleaning areas; the fish cleaning areas are open. The fish are sold from the floor or from an elevated platform. Ice is seldom used, in many markets the sellers are not licensed, and little attention seemed to be given to proper handling of the fish. There is, no uniform policy for operation of markets or specifications that are applied nationally. The markets at Sur, Seeb, and Barka do not have a supply of ice that is readily available. The market at Salalah has a 10 tonne "mobile" ice supply right across the street. The markets at Sohar and Muttrah have ice available in limited quantities because the ice plant is in the fish factory, which has first priority for use of this ice.

The preventive measures that might be taken are hygienic handling of the fish, as well as the regulation of time-temperature combinations. Appendix IV contains specific recommendations to improve fish markets.

All surfaces with which the fish comes into contact, such as floors, boxes, cutting and filleting boards and utensils, should be kept clean, so as to minimise contamination by spoilage bacteria - conditions which Omani markets fail to meet. All such utensils and equipment should be cleaned thoroughly at the end of each working day, and moveable equipment stored in a clean place; temperature is the most important factor affecting the quality of wet fish, and the lower the temperature, the slower the rate of spoilage. All wet fish should be maintained at a temperature as near as possible to 0 °C (32 °F) from the time of landing to sale; knives and other cutting utensils should be constructed of steel, with stainless or polypropylene handles; wooden handles are unsatisfactory. Cutting and filleting boards should be of the non-absorbent synthetic variety, such as polypropylene. Hard wood chopping boards are permissible but should be maintained in a good condition. Tanks in which fish is washed, counters, slabs, and preparation areas should be cleaned daily by washing and scrubbing with a hot detergent solution, sanitised with a compatible sanitizer, and rinsed with clean water. A combined detergent sanitizer used to manufacturer's instructions is also suitable; equipment and utensils should be thoroughly washed at least once daily in hot water containing caustic soda, or some other suitable detergent and afterwards rinsed in hot water (minimum 77 °C). If a sanitising agent is used as well as a detergent in the washing water, the temperature of the water may be reduced.

4.7. Factors hindering a fish safety control system

Food safety control has also been recognized as an important factor in the promotion of food quality (Onagoruwa, 1989). Based on observations conducted in this study, two of the weakest links hindering establishment for an effective fish safety control system in Oman are (a) analytical services and (b) inspection services. This weakness is mirrored by the experience of many other developing countries - see Chapters 3 and Appendix IX.

4.7.1. Analytical services

Laboratory services are a necessary condition for any effective food safety control system, yet laboratory services have often been found to be weakest part of food safety control systems in Oman. This might be because of insufficient funds to run or maintain costly and sophisticated equipment, lack of skilled manpower, or lack of awareness of the role of such a service. Without an effective laboratory service, however, enforcement of food controls will always be very difficult. Before 1998, the Department of Animal Wealth (DAW), at the Minister of Agriculture and Fisheries had the responsibility for controlling exports and imports of agriculture, meat and fishery products, issuing a permit for each shipment of product. The DAW did not have a laboratory for inspection of fishery products. Their only laboratory was a veterinary laboratory, which was used for animal diseases. Whenever they needed to conduct any analysis, the department referred the request for seafood analysis to the Ministry of Commerce and Industry. In 1998, after the ban on seafood products exported to the EU countries as a result of the requirement of the Council Directive No. 91/493/EEU to conduct microbiological examination of those seafood shipments, a section was allocated in the Marine Science and Fisheries Centre (MSFC) for this purpose (1999). This laboratory's work, however, is impeded by shortage of technical staff with the capacity to undertake the required analyses, lack of funds to purchase the equipment needed, and limited manpower for carrying out the increased workload.

Coordination between the Ministry's inspectors and the laboratory division is needed. Due to limited funds and lack of technicians, the laboratory conducts those analyses which are requested by fish companies to meet export requirements, but no hazard analysis is conducted for fish safety in other parts of the food chain, for instance, in fish markets or fish processing plants. It is important to conduct such hazard tests to identify and assess the magnitude of food hazards, so that account can be taken of them when food legislation is formulated.

4.7.2. Inspection services

The traditional inspection usually involves quick observation of products, practices and procedures. But this does not necessarily yield sufficient data on the basis of which preventive action can be initiated. In Oman and probably in other developing countries, inspection is often pre-arranged, and this prior knowledge of inspection time gives fish businesses the opportunity to make special efforts to impress the inspection officer(s). Practices, which lead to outbreaks of foodborne diseases, may be in evidence at night, and/or at times not particularly suitable for inspection. Food regulatory officials without the basic tools for inspection often rely on sight, smell and touch to decide on the safety of foodstuffs.

One of the major constraints on effective seafood inspections in Oman is that there are too many Ministries and departments involved in this task.

The Directorate General of Health Control (DGHC), Ministry of Regional Municipalities is responsible for food hygiene in food establishments (retail shops, market places, fish markets, and food and seafood processing plants) in all regions except for the Capital area. DGHC is responsible for issuing an annual certificate for food handlers (expatriates only) who work in the establishments. It does not use any written sanitation or hygiene standards for the fish processing plants. Depending on the region, the DGHC may inspect fish processing plants at least twice a year. It has 43 municipalities and about three people in each municipality who deal with food establishments. Most of the problems in food, as DGHC noted, are from contaminated ground water due to pollution from septic tanks. There is also a serious problem with blue fly in the fish markets and drying fish yards. When stronger action is required, DGHC must get approval from the Minister. The Ministry has product standards for food products, but none for seafood. There was no evidence in the study of food hygiene standards for application by Municipalities to seafood plants.

Muscat Municipality is involved in a scheme for the inspection of food establishments in the Capital area only; its major concern is inspection of employees' hygiene and structural inspections. Municipalities and the Muscat Municipality inspect fish establishments, food markets, and fish products at the market place and check fish processing plants primarily for workers' health certificates and for pollution, but they do not check the sanitation of fish plants or draw samples of product for testing.

The Department of Specifications and Quality Control at the Ministry of Commerce and Industry is assigned to develop a plan for inspections of food establishments, to be carried out by Municipalities and the Directorate of Environmental Health and Malaria Eradication, Ministry of Health. The Directorate has authority over food safety, water, and sanitation, as they have an impact on public health. Although having the authority to step in and take action on any problem concerning public health, the Directorate elects to act in an advisory role and to bring problems to the attention of the agency assigned primary responsibility. Most agencies take advice seriously and correct problems.

The Ministry of Commerce and Industry has, in cooperation with other agencies, developed 80 Omani standards for food products, but there are no Omani standards for fishery products. The Ministry has adopted Gulf Standard *21/1984 HYGIENE REGULATIONS FOR FOOD PLANTS AND THEIR PERSONNEL* but this standard is not applied to fish processing establishments. The Ministry carries out product analysis only at the request of foreign governments or industry.

The Department of Animal Wealth, MAF, inspects products and issues certificates for each shipment of fish, but there are no standards for products or establishments. The DGF requires licensing of individuals or organizations that transport fish, and requires use of approved fish boxes with ice, but this programme is only applies to exports and is not widely enforced.

Generally, based on the field survey, constraints could be summarized as follows: every department has its own procedures and methods; consequently, sometimes conflicts occur when two departments inspect the same fish establishment and try to enforce what they think is right, which may contradict the enforcement of the other. No cooperation exists between them, so establishment owners become confused. In addition, there is a general lack of trained personnel. The food inspectors in Oman are not adequately trained and lack professionalism and a good understanding of food safety.

Most of the issues raised by inspectors are structural rather than procedural, which reflects the lack of good understanding of food safety. The researcher found that there is no organised method or procedures to follow for sampling and there is a lack of cooperation and coordination between the food inspectors and the laboratory service. Moreover, there is no proper record keeping. Another factor that contributes to ineffective implementation of the functions of the inspection unit is a lack of adequate funding. The inspectors need efficient and reliable transportation to carry out their duties, but as a result of poor allocation of funds, transport facilities are very inadequate compared to the vast area to be covered, which leads to poor scheduling and coordination of officers' duties and poor execution of assignments.

To overcome such these impediments to a modern food safety service the researcher suggests the following:

- Surveillance of food safety should include all critical points where food may be mishandled, from production, processing, storage, and distribution to consumption.
- Fish safety inspectors should be trained to be able to correct faults and recommend improvements. Inspectors should be properly distributed to cover their activities, according to the needs and requirements of specific areas/regions.
- It has been noticed that in Oman, monitoring agents pay more attention to manufactured products and to manufacturing establishments. Often, the more critical areas are ignored or are not adequately monitored. Agricultural products, slaughterhouses and slaughtering practices, open-air markets and practices in these markets as well as in food transportation should be given more attention for effective consumer protection.
- Inspection activities should be better planned, more systematic, standardised, supervised and coordinated with laboratory work. There should be proper record keeping. Duplication of inspection activities by the different food inspection agencies should be analysed and corrected, in order to conserve resources and avoid waste.

- Good production and manufacturing practices in food industries should be encouraged. Codes of Practice should be developed as guidelines for manufacturing of different fish operators. It would then be the duty of food safety administrators to ensure that such information is available to manufacturers and processors.
- A "Certification Mark Scheme" could be developed for good manufacturing practice. This would provide an incentive for processors to establish their own quality and safety measures.

From the forgoing discussion, Oman needs an adequate fish control policy to ensure that national fish supplies are safe, of good quality and available in adequate amounts at affordable prices, to ensure an acceptable nutritional and health status for all population groups. Fish control includes all activities carried out to ensure the quality, safety and honest presentation of the fish at all stages from harvesting, through processing and storage, to marketing and consumption. It implies a national effort involving an integrated approach between government and all subsectors of the fish industry.

The researcher wishes to underscore the need for collaboration among government, industry and the consumer to make food control system work effectively. There is a need for multi-sectoral participation in the development of necessary laws, regulations and standards and the commitment of government to their enforcement through adequate monitoring, inspection and surveillance. Adequate training of people at all levels of the food control system should be a priority. The following actions need to taken by the DGF to implement a quality control and inspection programme in fisheries sector:

establishing a "Quality Control Programme" to ensure international acceptance and markets for fishery exports; it is recommended that the government and the private sector work together to establish a comprehensive programme to improve the quality of fish and fishery products;

- establishing a core unit to be responsible for quality control and inspection to begin implementation of a seafood plant inspection programme;
- conducting a quality control evaluation of all Omani plants processing seafood for export. Sanitation and hygienic deficiencies should be noted; a quality control certificate should be issued only to those plants that meet sanitation level and requirements. Only plants meeting these requirements should be allowed to export seafood. A definite time limit should be set to meet these requirements;
- developing and carrying out a comprehensive training programme for staff members of the DGF headquarters and regional in quality control and inspection. The programme should provide training in fish product standards, sanitation and hygiene techniques, fish product sampling, inspection and certification procedures, advanced inspection systems of HACCP and ISO 9000, laboratory analytical methods, and fish inspection system administration and operation;
- extending the activities of fisheries quality control certification laboratory at the MSFC;
- appointing a quality control advisor to provide assistance in establishing and operating the quality control laboratory, carrying out plant inspections, developing regulations and standards, and administering the overall programme.

Meanwhile, prior to the construction of a new plant or modification of an existing one, the regulatory authority has to analyse the propose plant projects, before construction.

The location of a processing establishment, its design, layout, construction and equipment, should be planned in detail with considerable emphasis on the technical, hygienic and sanitary conditions for food processing. A proper flow diagram of the operation should be prepared. Only a well organized workflow will assure the efficiency of the operation, avoiding cross contamination and undesirable delays on the processing line and producing a better quality products.

To create uniform operating practices, the regulatory authority has to analyse each product process and labelling, before the plant starts production (i.e., process definition, presentation of the product, raw materials used, ingredients, food additives, hygiene and handling) as well as product identification, including the name of the food, form of presentation, common trade names, storage instructions, weight, and processing date. This condition would help consumer health protection, allow for uniform quality of the product and facilitate fair practices in the fish and fishery products trade.

4.8. Conclusion

From the foregoing discussion, it seems that considerable waste occurs because of poor quality fish, due to poor hygiene in handling fish on vessels, in the market place in processing plants, and in distribution. Lack of ice and insanitary handling probably results in economic losses from an economic resource. A programme to encourage improvement in Product Quality Control should be undertaken to encourage improved handling of fish and shellfish and quality at every stage of operation.

A professional capability for fishery products quality control in the government and private sector is extremely limited. The DGF has a general knowledge of quality control and administers a quality control section. The people in the section are not trained professionally in quality control, but are familiar with the general principles of fish handling and quality, and encourage fishermen and the industry to use ice and improve the handling of fish. Other personnel in the market information and extension sector are generally familiar with the quality aspects of seafood. Specific expertise in inspection programme administration and operation, standards development, fish preservation technology, plant hygiene, and product analysis and sampling is lacking. The private sector has some experienced people, primarily from India, Pakistan, or other countries, who are entrusted with some specific quality functions in checking fish quality and in maintaining plant sanitation. The research shows that most of these people are not broadly trained, or familiar with quality control as practised in the United States or Europe. Some companies did not even have a designated person responsible for quality control. The College of Agriculture, Sultan Qaboos University, has a Marine Science and Fishery Technology Department, but no specific programme on quality control for food or fishery products. The Department of Animal Science has a fish processing course. The College plans to establish a Food Science Department, which would give some attention to quality control in food.

The general picture from the research is that a number of Ministries and Departments have been involved in food inspection without appropriate coordination of the work of the different government agencies. This has sometimes led to overlapping and even contradictory provisions, and to difficulties in their meaningful enforcement. Also, outdated laws and regulations have been issued which no longer meet the needs of the country. Changes in the social structure, in food habits and in modern fisheries and food technology are inadequately reflected in these outdated regulations. In addition, the administration, operations and duties of the fish inspection agency are not clearly separated from those of other agencies within the parent department. Staff or facilities, particularly analytical services, are used from other divisions within the same umbrella-agency or from other agencies.

Shortage of personnel and lack of personnel training are impediments to a good quality food safety service in Oman. Training facilities are also not readily available. Good management of food safety programmes depends on the ability of the administrators and supervisors to understand national policies, goals and objectives and to be able to direct efficient monitoring, inspection and laboratory services.

Most of the existing fish inspection services lack sufficient qualified trained personnel and physical facilities, power and funds to carry on the work. Inspection for the purpose of quality control is still relatively new. The fieldwork evidence is that only minimal inspection of fishery products is applied.

Existing fish inspection agencies mainly concentrate on licensing plants for the international market, carrying out laboratory analysis of end products, and issuing export certificates. Very little has been done to assist fish processing businesses in the improvement of the technology of handling and processing inside the plants; or the quality of fishery products sold at national level; or to improve product diversification.

It was noticed that low priority is given to promoting and enforcing GMP and effective quality control systems in processing plants. The inspection service devotes much of its effort and resources to the testing of products prior to export.
Food safety education is a key factor in the success of food control. It is needed for all food operators in the entire food chain, from production to consumption.

Farmers/fishermen handling food products and chemicals or mishandling food during harvesting and storage need food safety education. The food industries should be educated about GMP; distributors/retailers and even transporters of food need to know about proper food handling.

In Oman, there are very low levels of consumer awareness of food safety hazards and a lack of consumer participation in matters affecting their health and economic well being, including the right to safe and adequate food supplies. Consumers do not have easy access to food safety service personnel, even if they are available. A comprehensive education programme should be developed to educate fishermen and fish handlers in the proper icing and handling of fish. Although consumer education is necessary to facilitate better handling and quality, and to assist the industry in meeting regulatory requirements, this alone, without a regulatory framework, will not result in any significant improvement in quality. More pressure from consumers may be expected to improve the food safety service in Oman (as was the case in developed countries) and this can only be achieved by creating food safety awareness amongst consumers. Consumers' rights and privileges under the food law should be properly explained and people should be encouraged to notify food safety control officials of malpractices, contamination of food and unsanitary conditions in food establishments. Consumers will also be in a position to participate in food issues if food safety education is more widely promoted.

Food safety education should be included as an integral part of nutrition and health education. Also, education should be provided through the various public information services in the country. For example, the Ministry of Information could develop audio-visual programmes and educational materials on quality control, to be used by the government and the private sector to educate people in the proper handling of fish. These educational programmes would be based on principles set by the FAO codes of practice, to apply to Oman's fisheries. In the villages, women's groups, community leaders, religious lenders, schoolteachers or local government officials could help to spread food safety information. Visits could be made to daily open-air markets and talks/demonstrations could be given on food presentation and handling. Education in the proper handling of fish should be made an important part of the extension activities of the DGF. Many employees in the extension organization are knowledgeable in the proper handling of fish, but there is no formal programme of quality control.

Chapter Five

Strengthening a National Food Safety Programme in Oman

5.1. Introduction

National and international awareness of the importance of food safety is increasing as a result of the identification of emerging foodborne pathogens and new hazards such as salmonella, mycotoxins, bovine spongiform encephalopathy (BSE)[1], dioxin and residues from antibiotics from imported and domestically produced foods. The threats affect more than one country and in some cases more than one continent (WHO, 1996). Therefore, it is not possible for any one country, such as Oman, or other countries to remain isolated from changing demands of international requirements for food safety regulations.

Every country needs an effective food safety programme in order to protect the health of their citizens and to participate in international trade in food products. Trade is an important driver of a country's economic development in the current global economy. Consequently a food safety crisis can have social and economic consequences on communities (Unnevehr and Hirschhorn, 2000).

The primary responsibility for food safety lies with those who produce, process and trade in food, such as slaughterhouse operators, food processors, wholesale and retail

[1]Mad cow disease.

traders, caterers. It is their duty to ensure that the food they produce and handle is safe and satisfies the relevant requirements of food law and they should make sure that such requirements are met. However, the legal responsibility for food safety rests with governments.

This chapter examines the existing food safety control in Oman and possible strategies that can be adopted to improve it. The objectives are to investigate the present status of the food control system in Oman; verify and quantify observed factors impeding the effective and/or adequate functioning of the food control system; establish causal relations between present practices of food production, importation, processing, marketing, sanitation, water supply and problems of food control; and recommend desirable future action to be taken to setting up a food control strategy in the Sultanate. Generally, the information presented in this Chapter was based on:

- personal interviews to obtain relevant information and discuss problems with officers in charge at relevant Governmental Agencies;
- published and unpublished reports and/or documents pertinent to food control in general and food legislation, food regulations, circulars, decrees etc., in particular;
- field visits to relevant Governmental and non-Governmental Agencies, such as the Ministries of Health, Agriculture and Fisheries, Housing and Transport, Regional Municipalities and Water Resources, Commerce and Industry, and other private sector companies, to investigate;
- the activities undertaken;
- problems of food production and/or importation and food hygiene;
- entry points;
- health and agricultural quarantines;

- abattoirs;
- potable water stations;
- authorised testing laboratories to observe and/or investigate the conditions under which food is inspected and/or tested;
- other relevant establishments such as food retail markets to observe and investigate the conditions under which food and water are being handled, prepared and served.

This chapter is intended to assist the Omani government in strengthening its food safety programme as part of an overall food control and consumer protection strategy. The chapter should also be of interest to nongovernmental organizations, industry and trade associations, and consumer groups that have a vested interest in the safety of a nation' s food supply. This chapter consists of two parts. The first part evaluates food safety infrastructure, while the second part recommends ways and methods to strengthen the food safety programme based on international requirements.

5.2. Assessment of food safety infrastructure

To establish a food safety programme, it is necessary to start with an assessment of the existing food and water supply, food imported, exported and marketed, in order to identify specific needs, and then to develop an optimal approach to meeting these needs.

5.2.1. The administration of the Omani food industry

From the administrative point of view, and as far as food control is concerned, the Sultanate of Oman is divided into five areas: The Capital Area, the Rural or Regional

Areas, Dhofar Area, Buraimi Area and Musandam Governorate (see Fig 4.1). The Capital Area, which is the most densely populated area in the Sultanate, is administered by the Governor of the Capital and is divided into four regions: Muscat, Mutrah, Bawshar and Seeb regions, with one semi-independent municipality each. The Rural Area is divided into four sub-areas: the Sharquya sub-area (with 11 branch municipalities), the Oman Interior sub-area (with 8 branch municipalities), the Dhahirah sub-area (with 3 branch municipalities) and the Batinah sub-area (with 10 branch municipalities). All 32 regional municipalities have their headquarters in the Capital Area under the Ministry of Regional Municipalities. Dhofar Area is an autonomous body, administered by a Governor (who has the rank of a Minister) and comprises 3 municipalities. Each branch municipality contains a public health section. Food control activities are part of the duties and responsibilities of such public health sections. The Buraimi and Musandam Areas are administratively under the Committee of Regional Development. Their respective municipal public health sections do not perform duties related to food control, but are confined mostly to cleanliness and insect control.

Food products have traditionally played an important role in the economy of Oman, and this importance continued to grow until oil production began in 1967. Prior to the development of the oil industry, Oman's exports were largely composed of dates, limes, fish, tobacco, fruit, vegetables, hides and henna. The country was dependent on imports of durable and non-durable goods such as rice, tea, fabrics, pipes, furniture, machinery and cement.. In the mid-seventies, the oil sector became the mainstay of the economy and its main source of income and the relative importance of the food sector declined. Since then the economy gradually reduced its dependence on the oil sector, but it has achieved an impressive record of social and infrastructure development. According to the World Bank Development Report 2001.

Among other economic development and diversification plans of the Government is to establish and/or encourage income-generating projects in the field of agriculture and fisheries and food industries. Development expenditure on agriculture and fisheries includes development of new water resources and maintenance and improvement of the *Falag* system, wells and water canals.

Food production, processing, marketing and importation

The total arable land is some 83,360 hectares (excluding about 500,000 hectares of pasture in the south) owned by 83,200 holders (i.e. an average of one hectare per holder) and about 55% of this area (46,126 hectares) is located in the Batinah coastal area, a strip of about 25 kms wide, extending from north (at the Khatmet Melaha) to the south (at Ras Al Hamrah) between the Oman mountains in the west and the Gulf of Oman in the east (see Figure 4.1). In view of rainfall fluctuation and water resource constraints in general, the area actually under cultivation represents only about 53% of the total arable land.

The estimated total cultivated area under fruit trees represents about 70% (about 28,600 hectares) of the total cultivated land; being 70.6% for palm trees (799 million trees, 5.2 million of which are fruit-bearing); 10.13% for mango trees (356,004 trees of which, 155,166 of which are fruit-bearing), 6.9% for lime trees (784,630 trees, 508,904 of which are fruit-bearing), 6.9% for banana trees (2.66 million trees, 1.22 million of which are fruitful trees) and 5.26% for other fruit trees including coconut trees which occupy about 304.9 hectares (101,684 trees, of which 85,470 are fruit-bearing). The rest of the area under cultivation is usually grown with alfalfa and vegetables (Ministry of Information, 1997a). The total area under vegetables is 2,137 hectares. Vegetable crops include onion, garlic, tomatoes, horseradish, pepper, carrots, spinach, peas, beans, melon, cantaloupe and others. Such diversity in a limited area indicates the small production of each type of vegetable, with the exception of onion (537 hectares) and watermelon (409 hectares), which occupy about 44% of the area under vegetables (Ministry of Information, 1997a).

Due to the fact that agriculture in Oman relies principally on ground water, cultivated land is scattered in small and numerous plots, over many areas of the Sultanate, depending upon the availability of water. The potential for applying large-scale mechanization to overcome limitations of manpower is accordingly limited. Government plans for increasing food crops are directed towards increased productivity through vertical expansion. To achieve this objective, the Ministry of Agriculture and Fisheries has established 38 centres for extension services and 5 research stations to provide various services and aids to farmers, including improved seeds, insecticides, fertilizers, water pumps and other equipment and services. Some of these services are offered free of charge and others, such as fertilizers and water pumps, are offered at subsidized prices. A plant for natural fertilizers was also established to convert garbage to fertilizers. The Ministry of Education also established an Agriculture Technical School in Nizwa in 1979 (Ministry of Information, 1997b).

In 2000 the estimation of animal wealth indicates that the total number of livestock is 1,680,000 animals (317,000 sheep, 959,000 goats, 284,000 cattle and 120,000 camels). Veterinary services are offered through 11 centres distributed in the country. Annual poultry production is estimated at 1million tonnes; being 700,000 tonnes derived from intensive commercial production by 20 poultry farms and 300,000 tonnes produced by farmers (500,000 birds of 0.75 kg each) (Ministry of Development, 2001).

Slaughtering of livestock is carried out in small abattoirs where facilities and practices vary widely and in many cases are not in conformity with best practice. There is one big and modern abattoir, established in Muscat in 1980/1981, with a daily capacity of about 500-700 heads. The number of animals slaughtered daily in the small slaughterhouses is about 8600 heads. Among the inspectorial staff of the Muscat Area Municipalities is a veterinarian who may inspect the animals before slaughtering. In the Ministry of Regional Municipalities there is a veterinary section, but no qualified veterinarians are available. Supervision in abattoirs is mainly administrative. It is recognized that most of the slaughtering of animals is carried out outside the abattoirs. There is a Ministerial order which prohibits the slaughtering of animals outside the municipal abattoirs, but due to lack of qualified veterinarians, this Local Order is not applied rigidly.

Annual egg production is estimated at 50.75 millions; being 35.25 millions derived from intensive commercial production and 15.5 millions produced by farmers. To encourage animal and poultry husbandry, the Government subsidizes imports of animal feed and participated (by 60%) in the capital required for the establishment of an animal feed plant. There are 32 milk farms in the country producing about 115,000 tons of milk per year (Ministry of Development, 2001). Milk is pasteurised, packed and marketed locally. Problems of spoilage of pasteurised milk, especially during summer, are encountering further expansion.

The annual catch of seafood production reached 120,421 tonnes in weight, and OR 52.77 million in value in 2000 (Ministry of Agriculture and Fisheries, 2001). Although the country has around 1,700 km of coastline, and although there are a variety of fish species in Omani waters, the resources are almost certain to be close to being fully exploited. Expansion of the sector is expected, therefore, to come about through more efficient utilisation of the catch. Improved food safety, and the resulting better international prices, is a contribution to this. There is thought to be some scope for the development of aquaculture and the production of crustacean.

Manufacturing is one of the main sectors of the economy targeted for diversification. It is estimated that the manufacturing sector, which contributed 4% to GDP in 1997, reached 5.4% in 2000 (Ministry of Development, 2001). Since the domestic market is small, the growth in manufacturing will be for export and the following kinds of industry will be encouraged: industries using local raw materials; industries using gas as the main source of energy or feedstock; capital, technology and knowledge-intensive projects; projects that employ Omanis on as wide a scale as possible; downstream petrochemicals; industries that process raw materials or semi-processed goods for re-export; precision engineering industries, machine tools, machinery etc.

According to a statistical survey of industry published by the Ministry of Commerce and Industry in June 1999, there were altogether 812 manufacturing units in 1997, of which 427 were small, 315 medium and 70 large with combined output worth RO 675.6 million and employing 27,624 workers of whom 7,766 were Omanis (Ministry of Commerce and Industry, 1999). The survey showed that over half the units produced cement products and metals. Two thirds of the total investment was in these products as well as in foodstuffs and drinks, but the ready-made garment industry was the most labour intensive, employing 5,236 workers. Much industry is still concentrated in or near the Capital area, but the Government has plans which will bring manufacturing as well as commercial opportunities to other parts of the country.

With the exception of fresh fruits and vegetables (self sufficiency about 80%) and fish (self sufficiency almost 100%) and a certain amount of livestock, the country imports most of its food requirements. Total imports of recorded food supplies increased from 188,500 tonnes (116.9 millions US$ worth) in 1977 to 1.4 million tonnes (8.9 billions US$ worth) in 2000 (Ministry of Development, 2001). Recorded food imports for the year 2000 (Ministry of Development, 2001) were: livestock (1.71 million heads; being 985,000 for sheep and goats and 725,000 for cattle), red meat (210,000 tonnes), poultry meat (150,000 tonnes), milk and milk products (210,046 tonnes), and fresh eggs (117.1 million eggs). Other imports in the same year were: fruits and vegetables (1 million tonnes), sugar, sugar preparation and honey (221,000 tonnes), coffee, tea, cocoa, spices and preparations thereof (769,000 tonnes), miscellaneous food preparations (228,000 tonnes), beverages (800,000 tonnes) and vegetable oils and fats (569,000 tonnes).

Exports (2000) are confined to fresh fruits and vegetables (15 million US$ worth), dry and preserved dates (4.6 million US$ worth), dry limes (8.9 million US$ worth), fish mostly frozen, dried, salted and fresh sardines (37 million US$ worth), flour (11 million US$ worth) and other food products (1.5 million US$ worth).

A number of food industries are available in the country. These are milling of wheat, baking, bottling of carbonated soft drinks and spring water, pasteurised reconstituted milk, refining and packing of vegetable oil, date processing and the production of honey, animal feed production, some drying and salting of fish (sardines). Control over quality of products is exercised in well-developed food industries, notably the semi-governmental flourmill and animal feed plant in Muscat. Other plants depend upon the analytical services extended by the laboratories of the General Directorate of Standards and Metrology of the Ministry of Commerce and Industry.

Wholesale and retail markets for fresh and processed foods are distributed over many parts of the Capital Area and also in the other regions. Some markets are suitably designed, whereas in other parts of the Capital Area such markets are not suitably designed. Ready-to-eat meals are also popular. In general, many retail markets, restaurants and shops are not adhering to good practices. Control over quality, sanitation and hygiene in the various food marketing centres and restaurants, and by street vendors varies, and in general is not in conformity with current regulations/Local Orders and/or acceptable requirements.

Water resources and water supply

There are no rivers in the Sultanate of Oman and the country depends solely on surface and ground water for irrigation, drinking and other household purposes. The source of this water is said to be rainfall, which is relatively limited (100 mm. per annum on the average with a maximum that may reach 200 mm. per annum in some areas such as the Southern Region) and widely fluctuating. Some areas do not have rainfall at all (Ministry of Development, 2001).

Since historical times, the country has enjoyed the availability of water in quantities sufficient for agriculture and household purposes. The main source of water was the *Falag* system, which is composed of a well dug at the foot of a mountain where rainfall water accumulates, and a canal dug out from the bottom of the well, sloping gradually for some distance, that may extend several kilometres till it reaches the desired place. The canal can be a surface canal or covered as an underground tunnel. This system was gradually supplemented by pumping water from deep wells to cope with the increased demand for water, mainly for irrigation. The tendency of increased digging of wells and pumping of ground water has resulted, in recent years, in the over-pumping of ground water, with a subsequent decrease in the water table and increase in the salinity of water. This has been coupled in recent years with a sharp rise in water demand/water consumption, concomitant with the country's rapid development and immense improvement in the standard of living. In order to cope with this increasing demand for water supply, desalination of seawater started in 1976 where a desalination plant was established in the Capital Area with a daily capacity of 12 million gallons. Several desalination plants of lower capacity were established thereafter in different areas in the country. There are twenty other desalination plants in various parts of the Sultanate which produce a total of around one million gallons a day. The current Sixth five-year plan includes the construction of ten other small desalination plants in remote areas, as well as the construction and/or improvement of over 200 wells in remote areas (Ministry of Development, 2001).

Potable water in Oman is either distilled water (desalination plants) blended with sea water to give a final water of the desired mineral composition (about 170 ppm total soluble solids), distilled water blended with well water to give a final water between 400 to 600 ppm total soluble solids or well water of about 750 ppm total soluble solids (Ministry of Commerce and Industry, 2001). Most of the potable water stations are furnished with a chlorination unit for injecting chlorine to give a final concentration of about 0.3 ppm at the outlets.

Drinking water is distributed through a pipe-network to most premises of the Capital Area, Salalah, Sohar, Nizwa and Buraimi. Similar networks are under construction for some other major towns. The remaining towns and villages rely at present on water tankers, which pick up water from a variety of sources (deep wells, shallow wells, springs, *Falags* or desalination plants) and distribute it to houses. The quality of the water varies and some types may contain much higher concentrations of mineral constituents than those recommended by the FAO/WHO standards. There are also public water taps constructed by the Government in several villages. Drinking water can also be obtained by consumers from their own private wells or *Falags*. The cost of water varies according to source; water from public taps is free, the cost of piped water ranges between 0.001 and 0.003 O.R. (equivalent to 0.0028 to 0.0084 US$) per gallon, depending upon locality and purpose of utilization, whereas the private supply of water by tankers is a flourishing trade.

Water resources in Oman are supervised by a number of Ministries and/or Councils depending upon locality and purpose or utilization. As far as safe drinking and sanitation are concerned, the "Council for Conservation of Environment and Prevention of Pollution" under the Chairmanship of His Majesty the Sultan of Oman established in 1980 a special "Committee on Safe Drinking Water and Sanitation" headed by the Minister of Health with a number of Ministries as members. Among other duties and responsibilities, the Council guides Ministries involved in the management of drinking water.

Control over the quality and safety of potable water is the responsibility of the "Environmental Health Sections" of the different municipalities as well as the "Environmental Health Section" of the Ministry of Health in Muscat. Inspectors supervise the hygiene aspects of water resources and water at different spots in the distribution/consumption line. They inspect both private and public premises and water tankers and issue relevant permits. They also collect samples of water for chemical and microbiological tests from wells, *Falags*, public water-taps, houses, restaurants, hotels, and schools. Collection of water samples for analysis is based mainly upon complaints received from or about the sources concerned. Analysis of water samples is confined mainly to the chemical and microbiological laboratories of the Ministry of Health in Muscat and partly to the laboratories of the Ministry of Commerce and Industry General Directorate of Standards and Metrology, also in Muscat. The record indicates that 32% of the samples tested in 1997 (454 samples) were found unfit from the microbiological point of view. It is also highly improbable that the contaminated samples would meet standards set down in Council Directive 80/778/EEC relating to the quality of water intended for human consumption, or its successor Directive, 98/83/EC on the quality of water intended for human consumption. Most of these samples of water represent untreated water collected from wells and *Falags* (Ministry of Commerce and Industry, 2001).

Government organisation

Food control services in the Sultanate of Oman are part of the duties and responsibilities of the Environmental Health Sections of the different municipalities, in addition to the Environmental Health Section and Laboratory Sections (Chemical Laboratory Section and Microbiology Laboratory Section) of the Preventive Medicine Department of the Ministry of Health in Muscat.

Control services regarding imported and/or exported foods are the responsibility of the Health Quarantine Section, Department of Preventive Medicine, Ministry of Health, as well as the Agricultural Quarantine Section, with its two branches; Agriculture and Veterinary, of the Ministry of Agriculture and Fisheries. Both Quarantine Sections, Health and Agriculture, are stationed in Qaboos Port, the main entry point of food consignments in the country. Similar but independent arrangements exist at Raysout Port in Salalah, in the Southern Region. There are two other control points at Khatmet Melaha in the north (opposite to Kalba, on the border with UAE) and Al-Wagaga (at the border with Dubai, UAE). Plans are under consideration for the establishment of three other control points at Al-Qabel, Wadi Al-Gisy and Tamrid, through which unrecorded quantities of food consignments enter the country from UAE.

The High Consultative Committee for Food Affairs, which meets every three months, serves primarily as the co-ordinating and planning body in the field of food industry, including food control. It is chaired by the Director of the Department of Preventive Medicine, Ministry of Health, and comprises 10 members representing the concerned agencies; i.e. the Deputy Director of the Information and Public Relations Section of the Ministry Regional Municipalities, the Deputy Director of the Omani Chamber of Commerce and Industry, the Deputy Director of Internal Trade of the Ministry of Commerce and Industry, a Representative of Qaboos Port, the Director of Customs, a Representative of Qaboos Port Police, and four representatives of the Department of Preventive Medicine of the Ministry of Health in Muscat, being the Head of the Health Quarantine, the Head of the Chemical Laboratory, the Head of the Bacteriological Laboratory and the Head of the Environmental Health Section. The Executive Committee meets every few weeks and serves as the executive body for the High Consultative Committee. It is chaired by the Head of the Health Quarantine Section, and comprises six members; the Head of the Environmental Health Section of the Ministry of Health, the Heads of the Agriculture and Veterinary Quarantine Sections, the Head of the Environmental Health Section of the Muscat Municipality, a representative of the Food Standards Section of the Directorate General for Standards and Metrology within the Ministry of Commerce and Industry, and a representative of Qaboos Port.

The General Directorate for Standards and Metrology was created in October 1976 by the Sultani Decree No.39/76, as an additional General Directorate of the Ministry of Commerce and Industry. It is composed of two Departments: the Department of Standards and Metrology, with two sections, the Standards Section and the Metrology Section; and the Department of Quality Control with three Sections, the Laboratories Section, the Quality Inspection Section and the Industrial Pollution Control Section. As far as food is concerned, the Standards Section is responsible for preparing food standards. It is staffed by two food specialists. The Laboratories Section and the Quality Inspection Section are responsible for inspecting and testing food samples (imported, locally produced/manufactured, or displayed in the local markets) and water samples to determine their conformity to the Omani regulations. The laboratories also extend analytical services to governmental and non-governmental agencies and individuals upon request and against payment.

5.3. Evaluation of food safety activities

The establishment of a food safety programme should start with an assessment of the existing food safety infrastructure and policy and identification of the specific needs to develop an optimal approach to meeting these needs. This can be facilitated by reviewing existing legislation and regulations, food inspection activities and agencies, laboratory capacities, public health concerns, and priorities for export access. The results of this assessment would provide useful information to design a coherent and integrated approach for internal actions and external assistance to meet the specific needs.

As indicated earlier, the Sultanate of Oman depends heavily on the foreign market for its food requirements. Food consignments are imported from all over the world. They vary widely in physical and compositional characteristics, purity, safety, and overall quality as well as package size, type and labelling.

FAO (1991) defines food control as mandatory regulatory activity of enforcement by national or local authorities to provide consumer protection and ensure that all foods during production, handling, storage, processing and distribution are safe, wholesome and fit for human consumption; conforming to the quality and safety requirements; and are honestly and accurately represented by labelling as prescribed by law. Such a food control system should be able to safeguard the consumer against any immediate or long-term threat to health which may be caused by microbiological contaminants, hazardous pesticide residues, hazardous food additives, metallic contaminants, mycotoxins, spontaneous spoilage, pest infestation and subsequent wastage and/or disease outbreak; against poor quality or fraudulent food and in general against any characteristic in food which may adversely affect the consumer's health or abuse his acceptance or trust. It should also be able to safeguard the consumer against food which is of little or no nutritive value but could promote bad habits, especially among children and young people (FAO, 1999). In addition, such an effective food control set-up should be able to eliminate wastage of food supplies due to improper handling, storage, processing and/or labelling, restrict dumping and promote fair and smooth national and international trade.

Such an effective and adequate food control set-up needs to be based upon five important pillars: food standards, comprehensive food legislation, an active and effective inspection service, and an adequate analytical service.

5.3.1. Food standards

A food standard is a body of rules or legislation, defining certain criteria such as composition appearance, freshness, source, sanitation, maximum bacterial count, purity, and maximum concentration of additives which food must fulfil to be suitable for distribution or sale (Abalaka, 1999).

The quality of a food depends upon a number of characteristics, which may be the subject of food standards. Physical characteristics include, among others, colour, flavour, texture, turbidity, fullness of container, drained weight, odour, etc. Microbiological standards or criteria may also be specified (FAO, 1990). Reasonable definitions and local or national standards for food can be established to protect nutritional quality and promote honesty and fair dealing in the interest of consumers.

The Omani General Directorate for Standards and Metrology has so far issued 3 standards for foods: wheat flour, drinking water and non-alcoholic carbonated beverages: and 22 standards for methods of test and analysis of foods: one for wheat flour, 11 for drinking water and 10 for non-alcoholic carbonated beverages. The Sultanate of Oman is a member of the Union of Arab Gulf States, which recently decided to adopt the Saudi standards as unified standards for all Gulf States. The Saudi Standards Organization has so far issued 101 food standards, including 40 standards for methods of analysis and 6 standards for methods of sampling.

In addition, the Health Quarantine at Qaboos Port as well as the Environmental Health Sections of the Ministry of Health and the Muscat Municipality in the Capital Area have been issuing, on an ad hoc basis, directives, guidelines and/or circulars for inspectors, importers, food handlers, detailing requirements to be observed in the importation, handling, display and sale of foods. Examples include the manner of recording date of manufacture/production, and date of expiry on the food containers, medical requirements for food handlers, and sanitary requirements for food establishments/premises (good housekeeping, general cleanliness, water closets, and sewage disposal, food hygiene, ventilation and lighting, safety, fire and accident prevention). A draft food labelling standard is also being prepared by the Head of the Environmental Health Section of the Ministry of Health.

Food standards help in the effective application of food law and in the orderly marketing of food both at national and international levels. Elaboration of food standards would require an organisation or agency responsible for standards. Food standardisation requires careful consideration and assessment of production and processing methods, practicability and economic viability. Therefore, standards should cover, as argued by Igbedioh (1992): essential composition; permitted level of additives, contaminants and pesticide residue; microbiological specifications; hygienic provisions and codes of practice; method of sampling and analyses; packing, labelling and advertising.

In preparing such standards, the International Standards developed by Codex Alimentarius Commission would be a useful source of reference. Codex Alimentarius has published a series of International Standards for a number of food products, aiming to harmonise national food laws to remove technical barriers to food trade.

There is a need to establish a coherent standard that sets out specific food handling controls related to the receipt, storage, processing, display, packaging, transportation, disposal and recall of food. Other requirements relate to the skills and knowledge of food handlers and their supervisors, the health and hygiene of food handlers, and the cleaning, sanitising, and maintenance of the food premises and equipment within the premises. Such standards should apply to all food businesses, whether operating from a permanent building, a vehicle, boat or plane or at temporary market premises.

Another area where Omani standards are lacking is pesticides and veterinary drugs. Pesticides and veterinary drugs should be subjected to thorough testing and risk assessment prior to approval for use. In order to minimize the risk of high residue levels in food and also to avoid environmental pollution, they should be used according to the principles of Good Agricultural Practice and Good Veterinary Practice and only by persons who have received adequate training. In order to avoid the development of antibiotic-resistant microorganisms, the use of anti-microbial in food production should be restricted.

Pesticide levels should be monitored in food (including drinking water) and feed to ensure that they do not exceed established maximum residue limits (MRLs) and the results of such monitoring should be made public. When residue levels above the MRLs are found, this should trigger increased control of products from the same supplier/grower and to remedial action. Likewise, the levels of residues of veterinary drugs in relevant foods of animal origin should be monitored and the results made public. When residue levels exceeding the MRLs are found, this should lead to an intensification of control and remedial action at the source of the problem, usually the primary producer.

If food businesses comply with these standards they will find it easier to meet the food safety requirements of the food practices standard.

Finally, food standards are usually put into effect by an official public notification. Before this occurs, information should be obtained from various sources, including inspections, to determine current practices that will promote honesty and fair dealing. The information may also include the collection of samples to demonstrate accepted practices. After a standard goes into effect, it is the official specification for that food in the country. To bear the name of the standardized food, a product may contain only those ingredients and additives permitted in the standard, in the amounts specified.

5.3.2. Food legislation

An effective National Food Safety Programme must be based on appropriate food safety legislation that assures food safety and consumer protection, as suggested by Baptist (1989). Such legislation should be sufficiently flexible to meet the needs of a changing food sector, the introduction of modern technology and the development of new food products.

Law is used in society an instrument for social control and social direction. Catterrell (1984) described law as an instrument for social change which can be used effectively to change, moderate and shape people's attitudes and beliefs. It can also be used by the State to control and manage the economy. Page (1985) described law as an instrument which government uses to influence and shape our environment. Another definition of law is given by Paulus (1974) as a means of resolving conflicts between the lawbreakers and the law enforcers to the extent that public order is upheld. The establishment or updating of food laws and regulations is a necessary first step in establishing an effective food control system.

The nature and purpose of food law has been defined as follows:

> *Food law is the body of legislation of a country, which governs the production, handling, marketing, and control of foods. In view of the technical developments occurring in the food sector, and of the increased possibility of fraud and adulteration, food law should be designed in the first instance to protect the health of the consumer, in the second instance to protect the consumer against fraud and deceitful practices and in the third instance to encourage fair trade practices (Dawson, 1983).*

Food laws are among the earliest legislation known to man and date back to biblical times. The English food law of 1266 was to protect consumers from fraudulent trade and foodborne hazards (HMSO, 1978). Thus, it made provisions against the sale of short-weight bread and unsound meat (Paulus, 1974). Although food laws have existed since these early times, it was not until the 19th century and early 20th century that food laws were enacted in their present form. The British "Sale of Food and Drink Act" of 1875 was seen as a major catalyst to food safety control, and is considered as the basis for most modern food laws (HMSO, 1978).

Food laws are more necessary today than ever before in view of the present level of chemical usage and centralized processing in our food supply. FAO (1975) and

FAO/WHO (1976b) have outlined the structure, principles and main provisions of a modern food law. The topics covered in these sources include the following:

- basic purposes of the law;
- definitions of basic concepts;
- scope of the law;
- competence for implementation of the law;
- inspection and analytical procedures and facilities;
- enforcement, procedures for enforcement, penalties;
- food standards and general regulations;
- regulation of additives and procedures for the authorization of the use of additives;
- regulation of pesticides and other contaminants and tolerances relating thereto;
- packaging and labelling;
- procedures for the preparation and amendment of the regulations for implementation of the law;
- repeals and amendments to earlier legislation which may be affected by a new or updated act.
- the central advisory or coordinating body;
- protection of trade secrets and other confidential information;
- registration of specific foods and food premises;
- penalties.

The Sultanate of Oman has, as yet, no self-contained food law which would meet the present day requirements in the field of food control. Food control activities in the country are based on two articles of the "Law of Communicable Diseases" (Law No. 8 enacted in 1973). Article No.8 of this law authorizes the Minister of Health "to issue decrees listing the health/hygiene requirements in imported foods or other objects so as to prevent the spread of communicable diseases". Article No. 19 authorizes the concerned authorities "to destroy the detained, foods or beverages that are proved to be contaminated or liable to contamination".

The sole specific food legislation currently in force in the country is the Ministerial Order No. 17, issued by the Minister of Health in October 1983. The rationale given for the order was the responsibility of the Ministry of Health in safeguarding the public against infectious and parasitic diseases and food poisoning, which may spread through contaminated foods or beverages, preserving the nutritive value of foods which may be affected by contamination, adulteration or spoilage, and the public interest. The Order consists of nine basic articles, as follows:

- The first article permits the handling of foods provided they conform in their hygienic, physical, bacteriological and chemical characteristics to the Omani, or Codex Standards, respectively, whichever is available;
- The second article prohibits the importation of preserved or manufactured foods unless they are accompanied by a certificate issued by the relevant government authority of the exporting country indicating that the food is free from microbes or materials hazardous to health and assuring that food is completely fit for human consumption;
- The third article prohibits the handling of foods to which natural or synthetic colouring matters are added, except within the limits specified in the aforementioned standards with regard to type of colouring matter, degree of purity and ratio to food material; in such cases the colouring matter has to be recorded on the label of each unit;

- The fourth article specifies that preservative additives added to preserve or manufactured foods have to be pure and should comply in their type and ratio to the provisions of the afore-mentioned standards. The name of the preservative should also be recorded on the label of each unit;
- The fifth article specifies that the label of each unit of preserved or manufactured foods should bear the name and net weight of the food enclosed, its constituents in weight or ratio of ingredients as well as the name and address of packer, manufacturer or importer;
- The sixth article requires the embossment on the container of the date of preservation or manufacturer of the preserved or manufactured food as well as the expiry date;
- The seventh article specifies that containers used for packing, preserving, transportation, distribution or sale of food whether made of metal, glass, paper or any other material, should comply with the hygiene requirements specified in the aforementioned standards;
- The eighth article obligates all local food plants to follow the hygiene requirements in each step of manufacture. It specifies also that all plants and products be subject to periodic inspection performed by the relevant authorities;
- The ninth article prohibits the handling of preserved or manufactured foods or beverages unless the relevant official laboratories certify their fitness in the Sultanate. By article No. 10, the order invites all Governmental Agencies to execute the provisions of the Order, each in his scope of work.

In view of current trends in global food legislation and the requirements for international trade (e.g., the European Union is in the process of updating its approach to food safety legislation, moving away from "vertical" detailed compositional requirements and placing more emphasis on risk analysis and on "horizontal" general rulings that apply to all foods), Oman should strengthen its legislation by developing a comprehensive food safety law, that should clearly identify and limit the particular authorities, functions and activities of government agencies; define methods to enforce legislation and identify penalties for breaches of the law and clearly identify the responsibilities of the food sector and all individuals and enterprises involved in the food chain. It should also contain provisions to ensure food safety and consumer protection in matters other than those relating to health, such as fraud and deception; and provide a mechanism for the introduction of subsidiary legislation and specific regulations, such as codes of practice, that will contain specific details on such matters as enforcement procedures, regulations on hygiene, use of food additives and labelling, licensing of food premises and import/export regulations.

Developing and updating food legislation will be a complex task and will need inputs from the legal profession, food scientists, industry and trade professionals and knowledgeable consumers. The law and regulations should take into consideration existing laws of countries within the region and the legal concepts recognized at the international level, including international trade agreement requirements as suggested by Steinz (1998). This would facilitate official food control compatibility and harmonization with countries of the region. It is also recommended by WHO (1984) that the law be translated into the languages of leading trading partner countries to promote greater understanding of the requirements to facilitate import food compliance.

Basically, food law should be flexible enough to meet the needs of changing technology of food production and trade (FAO, 1999). To achieve this, the law should permit adequate regulations which will be sufficiently flexible to meet changing needs, e.g., by providing for the updating of the basic law. Regulations should be based on assessment of data on food; i.e. the composition, production and processing methods/inputs, storage, distribution and marketing, including advertising. Such regulations should include: general considerations, food hygiene, food additives, pesticides, food standards, labelling and packaging and advertising. Both the basic food law and regulations should be simple and clear for easy interpretation and enforcement. Jouve (1997) suggested that all laws and regulations concerning food control be published in a single document for use by interested parties. FAO, WHO and Codex Alimentarius Commission are useful sources of guidelines on food legislation.

5.3.3. Analytical services

Food control programmes require an analytical capacity to monitor the quality and safety of a food supply. A broad range of analytical capabilities is required for detecting food contaminants such as pesticides, pathogenic bacteria, foodborne viruses and parasites, radionuclides, environmental chemicals and biotoxins. Capabilities are also required to determine food adulteration and compliance with official food quality standards.

Laboratory services are one of the most important components of effective food safety controls, without which enforcement efforts will be very difficult (quoted from Antle, 1995). The laboratories involved in food control activities in the Sultanate of Oman are the Public Health Chemical Laboratory and the Food and Water Section of the Public Health Microbiological Laboratory of the Department of Preventive Medicine of the Ministry of Health, as well as the Chemical and Microbiological Laboratories of the Directorate General for Standards and Metrology of the Ministry of Commerce and

Industry; all located in the Capital Area. Plans are under consideration for the establishment of a Food Control/Public Health Laboratory in the Southern Area (Salalah) and at one or more of the other entry points (Ministry of Commerce and Industry, 2001).

At present, samples collected from all parts of the country are pooled into the Section of Environmental Health of the Department of Preventive Medicine of the Ministry of Health in the Capital Area, from where they are directed to the relevant laboratory, under a confidential code number. Samples collected and/or analysed include potable water, imported foods, foods displayed in the local market and/or ready-to-eat foods offered in the restaurants, hotels or canteens. The Chemical Laboratory of the Ministry of Health handles about 3,000-4,000 samples per year, the Microbiological Laboratory handles about 1,100-1,700 samples per year (Ministry of Health, 2001). Samples of potable water represent about 30-40% of the total samples to be analysed. The record indicates that about 32% of the water samples analysed in 1998 were found unfit as potable water due to excessive coliform count, and about 6-15% of the samples of canned foods were unfit due to spoilage, or non-conformance to standards and/or declared labelling. The Laboratories of the Directorate of Standards and Metrology handle about 2,000-2,500 samples per year; about 70-80% are water samples. Workload has increased due to the increase in the number of Omani food industries.

Both laboratories, the chemical and microbiological laboratories of the Ministry of Health occupy a very limited space in an old building. The chemical laboratory is staffed by analysts in food science, in chemistry and in botany, besides a Chief Chemist. The Microbiology Laboratory is staffed by a microbiologist, an analyst and a technician. Recruitment of additional staff members for both laboratories is under consideration.

Both laboratories are adequately equipped to carry out elementary tests related to physical and compositional characteristics of foods, simple analysis of food additives and microbiological tests, mainly coliform count. It is recognized that modern and sophisticated equipment is absolutely necessary, and such equipment has actually been requested, to enable the laboratories to cope with the increased and specialized tests required, as a first step towards strengthening the analytical service, through an overall strengthening of the different sections of the Department of Preventive Medicine.

The Public Health Microbiology Laboratory also contains a branch for carrying out blood and stool tests for food handlers. All food handlers have to pass yearly a medical examination to ensure that they are not carriers of diseases. They have to have a valid certificate for the purpose of renewal of their licence, visa or contract.

The Laboratories of the General Directorate of Standards and Metrology appear to have limited capability for carrying out a greatly increased volume and range of work. They do not have standards for private laboratories. They have a resources problem in that they can only sample shipments in areas near to the capital. They do not have the staff available for travel to places like Northern or Southern regions. There needs, therefore, to be an inventory of such facilities and an assessment of their usefulness to food safety control. This is one of the ways of cutting cost, especially since laboratory facilities are the most expensive aspect of food safety control, and this will also reduce the need to build more laboratories. Proper assignment of laboratory duties and efficient supply of laboratory materials will help in providing a good laboratory service. During the survey, the main constraints found to face laboratory services can be summarised as follows:

lack of in-service training, to update knowledge on new techniques and method of analysis;

- some analytical methods are very complicated and require expertise and equipment, which are not available;
- no proper coordination between inspectorate and laboratory division, due to the different departments being located in different ministries;
- lack of reference materials (books, manuals, documents, articles) relating to new development in methodology and standards, and
- not enough technician staff to carry out the increasing workload of analysis.

Moreover, the inspection service and the analytical service cannot function independently and the complementary nature of each activity to the other must be maintained in an effective food control set-up. Generally, routine testing is necessary to avoid any threat to health or the economy of the consumer and the country, and suspected violations can only be verified in the testing laboratory. In many cases, laboratory analysis is imperative to enable proper decisions to be taken as to the fitness acceptability of foodstuffs or conformance with regulated composition and/or declared labelling.

In its efforts to strengthen the food control services in the Sultanate, the Government has approved a project involving the construction of a new and modern laboratory to satisfy the Sultanate's needs for many years to come and has already allocated the necessary funds. In the researcher's view, consideration showed also be given to the establishment of a laboratory in the Southern Area (Salalah) to satisfy the needs of the Southern Area with regard to simple and urgent tests, though it can continue to depend upon the Central Laboratory in the Capital Area for more specialized or sophisticated tests.

The availability of sufficient reference material is essential for the effective operation of a food control laboratory. All technical staff, including inspectors, should have the facility and opportunity to consult books and scientific publications regularly. Therefore the establishment of a modern library with recent editions of books on food control and related subjects, such as food science, food microbiology, food hygiene, modern techniques in chemical, microbiological, physical and organoleptic examination of foods, together with national, regional and international works of reference on food legislation, food standards, codes of practice, and a complete set of internationally recommended methods of examination and analysis of foods, is highly recommended. The library should also contain a useful set of training materials and training aids. To improve the efficiency and effectiveness of the laboratory services the following is recommended:

- increase funding to laboratory services to enable more microbiological examination to be conducted to detect any contamination of food with pathogenic organisms such as *Salmonella, Shigella, Staphylococcus aureus, Bacillus cereus, E. coli, Listeria, Campylobacter, V.parahaemolyticus, Brucella, Clostridium perfingens, Clostridium botulinum*, yeast and moulds which might poses severe risks.
- build two more laboratories outside the capital, one in the northern, the other in the southern part of the country;
- develop standards and establish procedures for private laboratories to meet heavy demands for work;
- increase the number of laboratory technicians;

- improve infrastructure, equipment purchase, maintenance and reagents supply;
- intensify training of analytical officers and technicians; short courses, workshops and seminars will be very helpful;
- provide reference materials (books, manuals, documents and other publications) relating to new developments in methodology and international concerns;
- improve coordination between inspectorate and laboratory service especially with handling and transmission of samples and results;
- cooperate with university, research institutes and polytechnics;
- place seafood product inspection and analysis under the MAF laboratory, which should be developed to minimise bureaucratic bottlenecks for more efficient laboratory service, and
- establish regional analytical facilities. Such centres can undertake analytical services requiring sophisticated and expensive equipment and expertise. They can also serve as training centres for food analysts.

Moreover, management structures and operational procedures of laboratories in Oman should conform to the internationally recognized guidelines specified in the ISO/IEC Guide 25, detailing the General Requirements for the Competence of Calibration and Testing Laboratories[2]. The food safety authority should consider accrediting designated official food control laboratories to the objective criteria laid down in this guide, in order to obtain an independent assurance of the competence of the food control laboratory and of the validity of the tests and analytical data it produces, and with a view to gaining mutual recognition and international acceptance of the competence of the food control programme. Consideration must also be given to the participation of

[2]The 20th Session of the Codex Committee on Methods of Analysis and Sampling agreed that the following criteria be adopted by laboratories involved in official import and export of foods: International Standards Organisation (ISO/IEC) Guide 25: 1990. General Requirements for the Competence of

official food laboratories in Proficiency Testing Schemes which are analytical quality assurance programmes to ensure consistent laboratory performance as recommended by WHO (1996).

5.3.4. Inspection services

Inspection of food and food handling during production, processing, storage, distribution and preparation is a key element of food safety control. The purpose of food inspection is to ensure that food operators are complying with the requirements of the law and to ensure that the consumer is receiving a safe, wholesome and nutritious food (cited in FAO, 1999). Therefore, inspection occupies a key position as a link between producers, food handlers and consumers, on the one hand, and the food control service on the other.

In addition, food inspection and control play an important role in preventing foodborne illness with its attendant human suffering, misery and death. Maintaining a safe, nutritious food supply also helps to maintain the general health of the population reduces sick leave at work and reduces health care and hospital costs (FAO, 1990). Food inspection also plays an important role in preventing commercial fraud and adulteration of food, thus protecting the consumer from economic loss and ensuring that he or she receives full value for money spent.

An effective food inspection programme can also play a vital role in food security by helping to reduce food losses due to rodents and insects. It can also assist countries becoming involved in the international food trade by assuring importing countries that

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Calibration and Testing Laboratories; and the International Harmonized Protocol for the Proficiency Testing of (Chemical) Analytical Laboratories. *Pure and Applied Chemistry* 65: 2132-2144, 1993.

food products are manufactured, processed and stored under good manufacturing conditions in compliance with internationally recognized standards.

In Oman, inspection of imported food consignments is mainly the responsibility of the Health Quarantine Section of the Ministry of Health, located in Qaboos Port, at the Capital Area. With regard to unprocessed imported food crops, such as wheat and other cereals, green tea, green coffee beans, fruits and vegetables, among other things, the Agriculture Quarantine Section (also located in Qaboos Port) carries out inspection to search for insect or disease infestation. The Quarantine Section has a double-tunnelled steel fumigation unit under vacuum to fumigate certain consignments with methyl bromide to control certain insect infestations. Inspection of livestock against diseases is the responsibility of the Veterinary Quarantine Section (in Qaboos Port) of the Ministry of Agriculture and Fisheries. Large trucks loaded with imported food consignments entering the country through the road entry points are in most cases directed to the Health Quarantine Section at Qaboos Port for inspection before unloading and/or distribution in the local market. However, it is recognized that there are unrecorded consignments of imported foods and/or import/export trade of food going on through the road entry points, which are not closely controlled.

Inspectors of the Health Quarantine Section at the Port inspect food consignments, either alone or in co-operation with the Agriculture Quarantine Section as explained above. The Quarantine Section is authorized to take decisive action in certain cases where consignments are not in conformity with current regulations, directives and/or circulars, or where obvious signs of spoilage or inconformity to directives are present. In case of suspected signs of inconformity or spoilage, representative samples are drawn and forwarded to the relevant laboratories of the Ministry of Health for analysis. In some cases, analysis may be carried out at the Laboratories of the General Directorate for Standards and Metrology, Ministry of Commerce and Industry. Similar but independent arrangements are available at Salalah Port in the Southern Area. However, there are no testing laboratories. Samples are forwarded to the Capital Area for analysis. The establishment of a provincial laboratory in Salalah is under consideration. At the entry points at Wady Al-Gisy (south of Buraimi) and Khatmet Melaha in the north (near Kalba, on the border with Fujerah, UAE) there are two offices of food control with one health inspector each. The other road entry points, mainly on the borders with the UAE, have no arrangements with regard to control of foods.

Inspection at the food marketing centres, shops, restaurants, hotels, water sources/potable water supply and abattoirs, is the responsibility of the Environmental Health Sections of the different municipalities in the country as well as the Environmental Health Section of the Ministry of Health at the Capital Area. The responsibility of the latter Section is mainly technical guidance; however the inspectorial staffs are authorized to extend inspection services in the local markets at the Capital Area. Inspection services regarding foods extended by the inspectorial staff of all sections are part of the overall duties and responsibilities related to health and hygiene and environment in general, including control of insects and diseases.

The Inspectorial Staff of the Environmental Health Section of the Ministry of Health consists of Health Controllers (Health Inspectors) and Health Supervisors (Assistant Health Inspectors). The inspectors are graduates of the Technical Health Institutes who have received two year courses in public health inspection including food control, and the assistant inspectors have only elementary education supplemented by on-the-job-training.

Inspectors of the Environmental Health Sections usually inspect food premises, regarding hygiene and sanitation arrangements and practices, food handlers regarding health certificates, food shops regarding hygiene practices and in search for spoiled foods or foods not conforming to regulations (mainly the expiry dates) and water sources and potable water regarding hygiene and sanitation. Inspection is carried out at intervals of 1-2 weeks depending upon the inspector's judgment and whether follow up is needed. Inspection is usually performed during the official working hours, unless a specific complaint requires otherwise.

Inspection performed on foods is based on visual judgment. Inspectors are authorized to take decisive action in cases involving small lots of foods and where obvious signs of spoilage/deterioration or incompliance are available. Regarding bigger lots, a special Committee in which the municipality is represented takes necessary action. Samples also may be collected and forwarded to the laboratory for analysis as a routine work. Violating foods, the amounts of which differ from time to time, are usually destroyed.

The inspectorial staffs of the Environmental Health Section of the Muscat Municipality, with its three branches, is composed of inspectors (including a veterinarian) and assistant inspectors, some of whom are keen to benefit from any specialized training facility overseas. Other members of the inspectorial staff have been promoted to assistant inspectors/inspectors on the basis of their long service.

The Inspectorial Staff of the Environmental Health Sections of the Regional Municipalities consists of 11 inspectors (one inspector for each three municipalities), 8 assistant inspectors, and 11 junior assistant inspectors who have either primary or elementary education with on-the-job training.

The inspection service in the Sultanate of Oman varies widely from one area to the other. Inspectors have basic qualifications, which vary too greatly to make a fair general statement; education ranges from a academic degree to below middle/primary school level. Inspection is mainly based on personal judgement, taking into account the relevant local orders/directives or circulars. Inspectors and inspection committees are authorized to take decisive action in those cases where obvious signs of deterioration and/or violation are present. They are not provided with a unified detailed and comprehensive manual to follow in their day-to-day work, although this would be an invaluable aid, especially to inspectors with limited training, to ensure uniformity in inspection and sampling techniques. Generally, the main constraints observed during the survey and personal interviews were as follows:

- most inspectors are ill equipped for inspection activities (i.e., lack of basic equipment and facilities, such as thermometers). There is a lack of proper on-the-job training and induction of professionalism;
- there seemed to be a lack of adequate communication and collaboration between the field inspectors and the coordinating officers in the headquarters, the laboratories and public analysts. This causes problems in obtaining the right feedback for immediate enforcement action;
- there is a lack of cooperation from the food establishments;
- there is a lack of proper and efficient scheduling and coordination of officers' duties;
- conflicting areas of work between inspectors from different Ministries, cause confusion to food operators and reduce the effectiveness of enforcement;
- inspectors are open to all sorts of occupational hazards and no protection is given to them;

- regional (state) offices lack sufficient personnel to cover work allocation. They also have poor transport facilities;
- uncooperative attitudes of some quality control managers in the food establishments are also due to lack of legally backed regulations, and
- lack of local reference standards, poor library facilities and lack of analytical facilities for certain food products and contaminants also restrict enforcement.

Under the circumstances, and in order to give the inspection service the attention it deserves, as an initial and very basic step in the effective and adequate food control set-up, the number of qualified inspectors needs to be increased, especially for those municipalities suffering from a shortage of them. Abattoirs have to be provided with veterinarians capable of conducting pre- and post-slaughter examination of livestock and carcases. Slaughter of livestock outside abattoirs must cease, in compliance with current regulations. In order, also, to ensure uniform application of legal procedures, a correct administrative approach, uniformity in sampling techniques and inspection procedures coverage during inspection, the inspectorial staff of all municipalities need to be provided with a detailed inspectors' manual, which dictates exactly the manner in which they can operate. The manual could be prepared in both Arabic and English, to serve groups who command either of the two languages. FAO/WHO publications could be a useful reference in this regard.

In order for the inspection service to be comprehensive and effective, it should cover all entry points as well as the local market and establishments. The food inspector usually occupies an important position in the food control service. His duties are not limited to the "police type" action of discovery and seizure of food consignments and/or transmission evidence when a violation has occurred, but more essential is the preventive role which he can play by bringing about voluntary compliance with regulations for the sake of consumer protection, with prosecution only as a last resort. Food inspectors should therefore be quite familiar with the general principles of food science and technology, hygiene and sanitation and well versed in the requirements of laws and regulations currently in force in the country (which need to be up-dated and be kept current, as referred to under food legislation). They should also have background information in the areas of usage of pesticides in the production and storage of food crops, biological and metallic contamination of foods, use of food additives and food labelling and standards.

The importance of well-trained inspection staff should not be underestimated. Ideally, food inspectors should be academic graduates in food science and technology or graduates of the public health institutes with specialization in food control and further on-the-job training.

The inspectors' manual should in general deal with inspection techniques, which are applicable or common to all food manufacturing, processing and storage operations, as well as addressed to various aspects of sampling, specific inspection techniques, export-import surveillance, compliance, development of evidence, special investigations and foodborne disease control. Such a manual should not be taken as a substitute for training, since only qualified and trained inspectors can be expected to use the required techniques efficiently and understand the procedures involved.

FAO (1984) has produced a manual on food inspection, which provides excellent guidelines. It describes the general approach to food inspection and sampling methods and techniques. Consideration is given to the inspection of different food commodities, manufacturing equipment, environmental hygiene and sanitation, export/import control, pesticides in agricultural and legal/enforcement procedure. Considering the importance of proper food sampling in food inspection activities, FAO (1985) has also produced a manual, "Introduction to Food Sampling", which will serve for the training of food inspectors and as a reference guide.

It is of the utmost importance to strengthen the training programmes organized by some municipalities in general public health, to cover all areas of food control and such training should be offered to all inspectorial staff in all municipalities. Such training programmes need to be conducted in two levels and in both Arabic and English languages. Based on the constraints identified earlier, suggestions for a more effective and stronger inspection service are recommended by the researcher as follows:

- a unitary Food Inspection is recommended to be established under one agency;
- improvement is needed in transport facilities for inspections and its allocation to the different units;
- number of inspectors should be adequate and commensurate with the workload to be performed;
- officers' duties must be properly scheduled;
- coordination and collaboration between laboratories, head office coordinators, and field staff should be strengthened;
- all inspectors should be properly trained in food science and technology. In particular, on-the-job training with regular workshops and seminars are desired. Also, short courses and constant exchange of idea among inspectors will be very helpful;
- proper documentation and recording of inspection work is needed; a resource centre for information on inspectors' activities, should be desirable;

- prior to establishment of suitable regulations for quality control, new firms starting in the production and export of fishery products should be subject to intensive review of sanitation and product handling practices based on HACCP system and GMP requirements, as well as product inspection to ensure that exported products are of satisfactory quality;
- the HACCP system should be employed as an inspection checklist or procedure (see section 5.4.3), and
- inspectors should be familiar with relevant legislation and regulations so that they may provide intelligent answers regarding the basic intent or purpose of the legislation.

Finally, the inspection role should make sure that food is handled, stored, manufactured or processed, shipped and marketed in accordance with the requirement of law and regulations. This function may also include investigative authority to determine the cause for foodborne illness outbreaks, food product quality defects, consumer complaints, in addition to the traditional activities of inspection of food facilities and the collection of food samples. There should also be authority to investigate and collect evidence which demonstrate responsibility for violations of the law or regulations.

5.4. Preparation of a national food safety strategy

Based on the survey, it seems clear that the existing food safety controls in Oman are not properly integrated in food policies. The issue has not been given much political recognition as a major factor affecting food availability or as a way to minimize the economic loss from poor quality (as in the case of the fishery sector, see Chapter Four).

It was noted that food safety as a strategy was still being carried out on an ad hoc basis. Food safety strategies are not adequately planned and properly implemented.

Food safety control elements, analytical, inspection services and necessary legislation (food law and standards) are still not fully developed. This can result in duplication of functions, and conflicts in official food control activities, and a waste of limited national resources. It may also lead to confusion in the food industry when enforcement procedures lead to unequal consumer protection, discrimination between sectors, and national trade being hampered. Absence of coherent national food control programmes and lack of interagency cooperation impact negatively on international trade, as the confidence will be eroded as to the credibility of the food control service. The organisation, management and coordination of food safety strategy are recommended.

The constraints observed on food control in Oman during the field survey can be summarised as follows:

- general lack of awareness of the importance of food safety as a strategy and lack of government priority to organise a programme to monitor food safety control;
- lack of food law and legislation in issues related to food safety. Insufficient regulations to back the Law on repression of fraud (see section 5.3.2);
- insufficient trained personnel in the Ministries to cope with food safety problems;
- insufficient funding for food safety control;
- inadequate laboratories;
- ineffective planning and policies by the government;
- poor infrastructure, especially transportation and inadequate storage facilities that result in heavy post-harvest losses;

- poor and inadequate processing and preservation technologies;
- poor marketing and distribution system, with too many middle traders;
- poor consumer attitude lack of demand for quality, safety of food and better service;
- poor educational status of farmers/fishermen and other food handlers and lack of food safety education causes insufficient knowledge in proper food handling, and general food safety values;
- food distributors in particular have the following constraints and problems.
- lack of Government control of prices and monitoring of food distribution. Because there are many middlemen in food trade, none of them take the responsibility for food safety;
- inadequate market spaces for traders because markets are not properly constructed;
- lack of water and general sanitation control system for markets, by local government authorities.

On this basis, the introduction of a new modern food control system could be considered as a vital step. Planning is necessary to ensure the effectiveness of such a system and it should be appropriate and compatible with social, cultural and economic conditions of Oman. Without using this approach, food service operations, food manufacturers, distributors and other members of the food chain would find it difficult to cooperate. Efforts to force improvements could lead to results that are contrary to those expected.

The development of a national food control system should not be considered in static or isolated terms. It should evolve in parallel with the general food availability of a country, regularly taking knowledge of changes in marketing; distribution consumer expectations and the food supply itself. The impact of these factors should then be considered in relation not only to the consumer but also to the food industry and trade. Clearly, the new system should be built slowly and carefully, with education as the cornerstone of the process, as suggested by WHO (2002).

From the foregoing discussion and for the purpose of the strengthening food safety strategy in Oman the following measures/steps are strongly recommended: administration and control, proper planning/information gathering, monitoring and evaluation. Each of them will discussed in the following paragraphs:

5.4.1. Administration and control

Good administration is necessary to ensure effective food safety control. There should be a coordination of all activities relating to food control, in the light of the WHO (1996) report that administrative problems reduce effective control of food safety. Food safety services in Oman exist in many Ministries and Departments and there is very little coordination of activities, rather there are conflicts and duplication of work and waste of scarce resources. They create confusion and operational difficulties for the food establishment, as well as wasting limited resources. Administrative constraints are also seen in the long and complex bureaucracies common in government establishments. These cause delay, rather than expedite delivery of service.

An administration may either act centrally or locally, depending on national preferences, but coordination at top management level must be centralised. WHO (2002) suggested that a good model for an effective food control programme is one with a centralized administration with the overall responsibility for policy, food legislation and coordination of services, with necessary delegation of powers, if and when required (see Fig 5.1). This might lead to a more efficient and cost-effective system where policy needs can be prioritised, human and financial resources required to implement the policies can be estimated, the scientific capability to support policies can be determined, and a management review process organized.

In order to achieve such a structure in Oman, a Food Safety Committee (FSC) or similar body could be established. The FSC should have highly qualified staff in sufficient numbers, adequately trained and properly equipped to carry out clearly "National Food Safety Policy" duties. The responsibilities of the FSC may include, but need not be limited to (WHO, 1996):

- approval or rejection of food additives;
- approval or rejection of pesticides and veterinary drugs;
- monitoring and surveillance of contaminants in food;
- development of novel foods and processes;
- microbial food safety;
- coordination and facilitation the investigations;
- setting up the necessary liaison groups involving the food industry, consumer and research bodies; and
- providing guidance and support to policy makers on food safety issues.

The FSC should be responsible for drafting a Policy Document on food safety and consumer protection that defines the national strategy, goals and objectives for food safety. In formulating this Policy Document, the FSC should be aware of the standards, guidelines and recommendations of the Joint FAO/WHO Codex Alimentarius

Commission, and the work of international organizations such as WHO and FAO in the area of food safety and food control. In addition, the FSC should be aware of the functions and activities of the World Trade Organization (WTO), especially in the context of the rights and obligations of WTO Members under the Agreement on the Application of the Sanitary and Phytosanitary Measures.

The FSC should coordinate the work of Expert Panels made up of representatives from government, industry, food research institutes, consumer groups and academic organizations. Such panels could be assigned specific tasks in drafting policy papers on specific food safety issues for presentation to Ministers for final decisions.

As the first step for its duties, the FSC may organize national conferences or workshops as part of the consultation process for developing a national strategy and highlighting priorities and activities for government consideration.

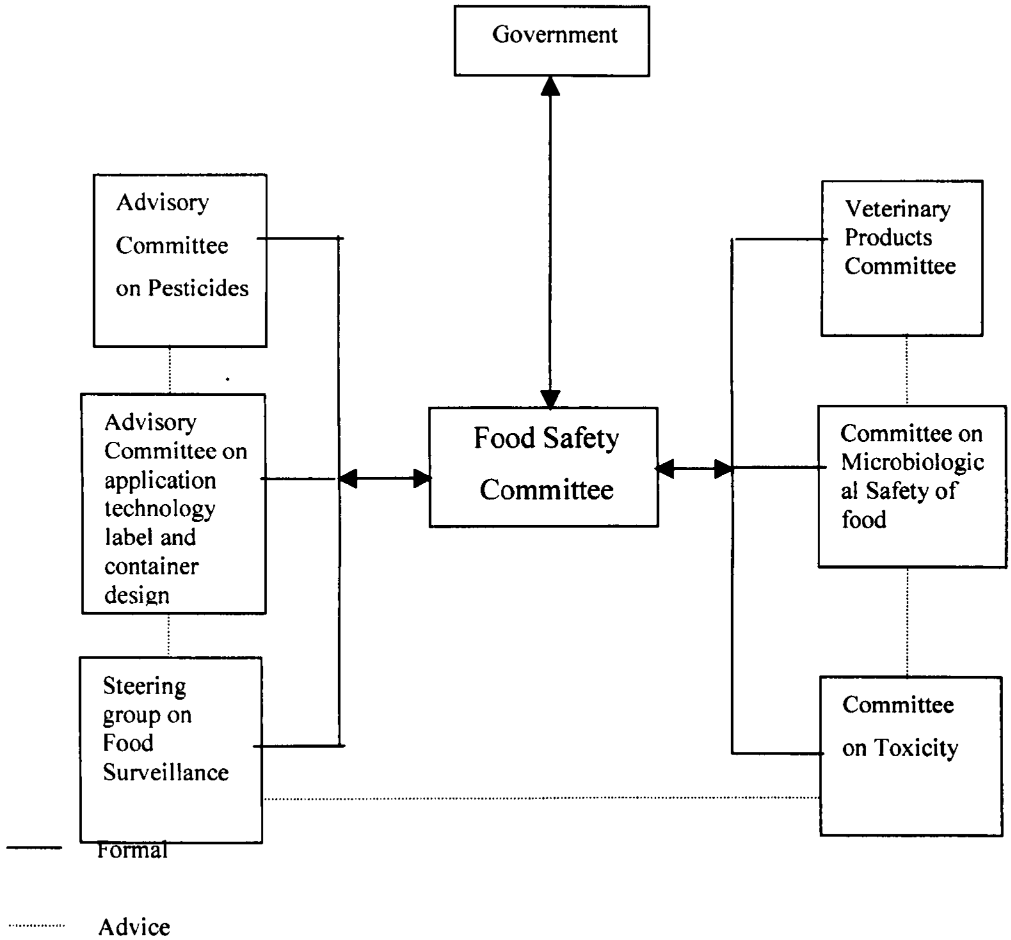

Figure 5.1. Government advisory bodies (Adapted from UK Government's white paper 1988)

5.4.2. Research and data collection

Governments in Oman have the responsibility to support research and collection of information especially on foodborne disease, through epidemiological investigation and surveillance. Todd (1996) argued that information on food safety concerns is necessary when setting priorities for allocation of resources, for consumer confidence in the food supply, and for supporting trade through exports. As part of the National Food Safety Programme, governments need to develop a strategic plan to collect and evaluate information on foodborne disease and hazards associated with the food chain.

Governments should require objective and sound scientific advice on these food related problems. Such advice could be obtained from a number of independent expert committees or working groups under FSC. This can be achieved by:

- establishing a steering group on food surveillance to review the possibilities of contamination of any part of the national food supply and to report to Ministers responsible for food safety and quality, with recommendations to ensure that the national diet is both safe and nutritious;
- establishing working groups or advisory committees on such topics as the microbiological safety of foods, toxicity of chemicals in foods, novel foods and processes, and on pesticides and veterinary products, and
- establishing a working group for review of the surveillance and reporting system for foodborne diseases and to provide recommendations for improvement of morbidity and mortality data collection (see Fig 5.1).

Proper planning of food safety strategy is necessary. Estimating is not good enough; accurate data are needed. An official foodborne hazard reporting system should be established. Records of illnesses caused by diarrhoea or by bacterial infections should be available in the departments of the Ministry of Health. A proper record of foodborne illnesses could yield the information necessary for food safety planning. Information documentation and preservation should be undertaken; such information would include research data based on all aspects of food composition, operation, and consumption, especially as it relates to the health and economic well being of the nation's population. Information about food hazards, or a mechanism for collecting such information, is currently non-existent in Oman, despite its importance for policy making. Other types of research such as basic research concerning food composition of local foods and effects of processing techniques on food have not been given adequate attention, and where such information exists, it is not properly translated into practical application.

Surveillance of foodborne disease

Developing an effective strategy to establish a food safety programme and reduce foodborne disease requires accurate reporting, epidemiological surveillance and information related to the potential hazards in the food supply. The absence of this information inhibits the implementation of effective food safety control measures and contributes to the failure of governments to commit the necessary resources to address the problems.

A food safety programme needs information to set priorities, develop policies, monitor progress and evaluate outcomes (WHO, 1989b). This information might include: contamination of foodstuffs at different stages of the food chain (production, processing; distribution, storage, preparation practices) and the impact on food safety; food consumption patterns; and occurrence of foodborne diseases and factors leading to them (Motarjemi et al., 1995; Todd, 1996). This latter information is obtained through an epidemiological surveillance[3] programme. Surveillance of foodborne disease is an important component of food safety programmes at all levels of government and within each type of food industry (CAST, 1994; Guzewich et al., 1997; Todd et al., 1997). Thus, epidemiological surveillance of foodborne illness is fundamental to the planning and management of food safety programmes.

[3]In this study, the word "surveillance" refers to the systematic collection and use of epidemiological information for the planning, implementation and assessment of diseases control.

Surveillance is defined as a continuous and systematic process that consists of (a) receiving notification of illness, (b) investigating incidents and reporting findings, (c) collating and interpreting data, and (d) disseminating information to those who are empowered to take appropriate action (Guzewich et al., 1997; Wall et al., 1996b). Surveillance has traditionally served three purposes: (1) disease prevention and control, (2) knowledge of disease causation and (3) administrative guidance for preventing the diseases in the future (Bean et al., 1997).

Although surveillance does not necessarily include direct responsibility for control activity (Wall et al., 1996b), the final link of the surveillance chain is the application of this information to prevention and control (Guzewich et al., 1997). Thus, foodborne, disease investigations enable policy determinations, and provide a basis for legislative actions and for the development of intervention strategies and research investments. Furthermore, the frequency of foodborne disease provides a measure of the effectiveness of the legislative and control programmes (Notermans and Van de Giessen, 1993; O'Brien et al., 1998).

In order to achieve the above objectives, various surveillance methods may be employed. Any choice of method will depend partly on the objective under consideration. The objectives and methods of surveillance of foodborne diseases may vary between countries depending on the availability of resources and the relative importance of foodborne diseases compared with other causes of morbidity and mortality. There are four main national systems by which data are collected (WHO, 1995b; WHO, 1997; Wall et al., 1996b):

- records for registration of deaths and hospital discharges;
- disease notification, and

- outbreak investigation.

Each will be considered in turn.

Registration of deaths and hospital discharge diagnoses

Registration of causes of death may in a limited way contribute to estimating the size of the public health problem of foodborne diseases and their trends. Infectious diseases for instance, overall have been shown to be an important cause of death in the United States in recent decades (Pinner, 1996).

In Oman, physicians usually complete a death certificate when a person in their care dies. The certificate should indicate the cause of death, name, address, sex, date of birth, and date of death of the deceased. Moreover, in all hospitals in the country, hospital discharge diagnoses should registered by age and sex of the patient and include other information such as the duration of stay.

The causes of death and hospital discharge diagnoses are usually classified according to the International Classification of Diseases (ICD), which is updated regularly (WHO, 1992).

Information on death certificates may be analysed centrally by Ministry of Health, annual reports may be produced, tabulating the number of people who died from various diseases by age and gender. For some diseases, occasional reports may be produced by the Ministry of Health. Hospital discharge diagnoses may be also analysed locally in the hospital concerned, or nationally.

Notification requires the physician to diagnose the disease validly and reliably (CDC, 1988). In Oman, the physician should be aware that the condition is notifiable and should have some incentive to notify, for instance because notification is "legally required" or because meaningful action can and will be taken. Notification is likely to be more complete if the disease is more serious, is perceived to spread easily from person to person, and if preventive measures are available (Skirrow and Blaser, 1992).

Reports by medical practitioners may be used to identify outbreaks, as discussed below under outbreak investigation (Djuretic, 1995). Notifications and reports of disease may also be used to describe the epidemiology of infectious diseases and to monitor trends in disease incidence. Examples are seasonal variation of foodborne intoxication in the United Kingdom (Sockett, 1992).

This information may be analysed centrally by Ministry of Health, for instance, in order to identify national trends.

The system would be extremely useful to be applied in Oman for detecting serious problems that are relatively rare (cholera, haemolytic uraemic syndrome due to E. coli O 157). It could be used as an early warning sign leading to outbreak investigation, thereby contributing to understanding of the epidemiology of foodborn diseases.

Outbreaks are detected by various means. Health workers, including medical practitioners, may note a shared exposure among self-reporting cases and report the cluster of cases to public health authorities, or they may routinely report selected conditions voluntarily or as required by law (e.g. botulism, cholera, haemolytic uraemic syndrome, bloody diarrhoea, listeriosis) (D' Argenio, 1995; Cameron, 1995; Tozzi, 1994; Riedo, 1994; Davis, 1993; Knubley, 1995; Orr, 1994).

In Oman, for example, members of the general public or institutions such as schools, universities or places of work may detect an outbreak, for instance after a shared meal at a restaurant, canteen, party, weddings, funerals, reception, field day or conference. Outbreaks may be relatively easily detected and investigated if those who have been at risk of exposure are known, e.g. airline or cruise ship passengers (Eberhart-Phillips, 1996; Benoit, 1994; Lew, 1991), and populations in institutions such as hospitals, nursing homes and prisons (Djuretic, 1995; Evans, 1996; Lo, 1994). Laboratory surveillance may detect outbreaks, particularly those spread over a region or country (Sockett, 1992; Evans, 1996; Davis, 1993). An outbreak may be anticipated and investigated after the detection of an increased risk of exposure, for instance by contaminated water (Gutteridge and Haworth, 1994).

In Oman, outbreak investigation may carried out by various disciplines, including public health physicians, epidemiologists, food safety officers, environmental health officers and microbiologists. Outbreak investigators should analyse and report as soon as possible to prevent additional cases. National compilation of reported outbreaks may be done annually or once every few years, to enable trends to be monitored.

Results of an outbreak investigation should be utilized immediately as the basis for taking rational measures to control the outbreak itself, such as withdrawal of the implicated product or adjustment of the production process. Results may find a wider application if the identification of high-risk foods or high-risk food practices is used for the prevention of further outbreaks. Publication of results is, therefore, very useful for health policy-makers and for the producers, distributors, prepares and consumers of the food concerned. Outbreak investigation may also contribute to knowledge of the symptoms, dose-response relationships, and incubation period of the infection concerned and contribute to risk assessment (Benoit, 1994; Mintz, 1993; Aucott, 1995; Glynn and Palmer, 1992).

Outbreak investigation is useful in that it responds to public demand and can provide timely information to prevent further cases of foodborne disease. It may also be a unique source of information on routes of transmission of specific pathogens and for the identification of high-risk environments and high-risk food-handling practices (Sockett, 1992; Djuretic, 1995; Alexander, 1995). But in Oman it may face major limitations, due to the high resource requirements in terms of skilled manpower and laboratory facilities.

5.4.3. HACCP as an inspection tool

Inspection activities are changing. On-line inspection based on sight, smell and touch is no longer sufficient and it is recognized that controls need to be enhanced in order better to address invisible biological and chemical hazards. New approaches for regulatory inspection and new technologies are being implemented as part of an integrated approach to enhancing food safety. Unnevehr and Jensen (1996) argued that HACCP based risk management approaches provide a basis for the strategic investment of inspection resources to maximize the effectiveness of inspection activities based on a better understanding of food safety risks and the management of those risks by industry.

The HACCP system has proved to be a powerful tool in identifying and assessing hazards in food and establishing necessary control measures (FAO/WHO, 1997b). Where epidemiological surveillance of foodborne diseases is weak, application of HACCP to food processing and food preparation can be an effective alternative and/or complementary measure for identification faulty or high-risk practices (NACMCF, 1992). However, the hazard identification component of the HACCP system can be greatly strengthened if based on scientific and reliable epidemiological data on foodborne diseases.

In Oman, the application of the HACCP system as inspection tool/method could aid inspection by regulatory authorities and promote international trade by increasing confidence in food safety. In contrast to HACCP, quality assurance, when applied, is often carried out by end-product testing. The major disadvantage of this approach as stated by de Sitter and de Harr (1998) is that it is ineffective because terms contained in laws are frequently of a general nature, they need to be applicable to different settings, these terms leave much to the discretion of inspectors who may fail to distinguish between "important" and "relatively unimportant" requirements. The latter is also due to the undifferentiated uniform weight of requirements in regulations. Also, any official inspection is limited with regard to time. Thus, the inspector's observations relate only to a portion of a particular process at a given point in time.

Responsibility for HACCP implementation

The main responsibility for the implementation of a HACCP-based approach to food safety lies with policy makers and planners who have the mandate to facilitate the adoption of HACCP systems; government authorities, including legislators, regulatory food control officials and health education bodies; and industries involved in all stages of the food chain. In addition, the following groups also have an important contributory role to play in the successful introduction of HACCP systems: academia, training and research institutes, nongovernmental organizations, and consumers.

The Government in Oman should provide leadership for the implementation of voluntary safety assurance programmes, through its various food control bodies. It needs to provide extension services to advise the food industry in the development of voluntary safety assurance programmes based on HACCP (e.g., establishing a HACCP steering group); it needs to promote a common understanding of HACCP systems within the food control services, the food industry and consumer groups and to promote partnerships and cooperation with all interested groups.

The responsible Ministries and municipal authorities should investigate the hygiene status of street-vended foods, the food handling practices of street vendors, and facilities and settings. Based on the results of this investigation and on risk analysis, a strategic plan for intervention should be developed. It is suggested by the researcher that starting points for a strategic plan for intervention could include, but not be limited to:

- organizing a national seminar on the HACCP system for policy-makers and senior personnel in food industries;

- organizing introductory workshops on the HACCP system for food inspectors and industry quality assurance personnel;
- introduction of a food safety certificate scheme for food premises that comply with training and inspection criteria, and
- development by joint industry/government working groups of industry guides for introducing the HACCP system in specific food sectors.

Steps in implementing a HACCP programme

Because HACCP is heavily based on epidemiological knowledge, a HACCP programme should be built up from an active foodborne disease surveillance programme (Bryan, 1981b). All of the potential hazards in the food chain (biological, chemical, or physical) that may cause an unacceptable consumer health risk should be analysed, from growing, slaughtering, and harvesting to manufacturing, distribution, retailing, and consumption of the product. This can be done by surveying all establishments in the relevant jurisdiction category in a risk assessment process, and identifying those establishments most likely to be involved in foodborne disease outbreaks, based on epidemiological experience and knowledge of food microbiology. The regulatory authority should publish these potential hazards for each product and propose guidelines for the application and implementation of the new quality control programme to the industries as a model system. The main effort of safety assurance of the regulatory authority and food processing industry will then be directed towards critical control points and away from endless final product testing. This will assure a much higher degree of safety at a reasonable cost. Therefore, all food service operators should be informed about the change in approach from the beginning, and should be involved in the planning and implementation of the programme. Such a programme should identify problems requiring immediate response, as well as trends or patterns in contributing factors that require special attention (i.e., critical control points).

The establishment's evaluations should involve an interview with the operator to identify high-risk foods and the steps involved in preparation to identify possible critical control points. A validation step is next, in which the inspector walks-through the preparation process in the establishments to confirm suspected opportunities for contamination, survival and growth. This step might include temperature measurements or other testing as needed. The final step is the confirmation of critical control points and the development of monitoring procedures with the operator.

The processor should identify the hazards associated with the products and processing environment. Hazard analysis and risk assessment should be conducted extensively. The industry should have sanitation, hygiene control and GMPs as a prerequisite programme. Once the hazards are identified, critical control points can be easily determined using a decision-tree approach, keeping the critical control points to the minimum necessary to control product safety. Next, processors should develop written HACCP plans and submit them to the regulatory authority for verification. HACCP plans will be subject to evaluation to verify that a satisfactory quality control programme verified by the regulatory authority is in place and is functioning satisfactorily. Processors that meet these requirements should be monitored periodically to confirm that they are in compliance with the requirements and that the critical control points are closely monitored. The plant should have at least one person trained on the applications of HACCP.

The regulatory authority should assess the HACCP programmes of the processing plants in three ways as recommended by Ababouch (2000):

- verifying the documented programme to the processing conditions of the establishment;
- conducting independent inspection of products and facilities, and
- auditing the plant's quality management activities at critical control points.

This third method relies heavily on plants' records. The regulatory authority should examine these records and perform independent inspections to verify their accuracy. The results of these three types of inspections will indicate how effectively the plant's HACCP programme is operating and this, in turn, will determine the frequency of inspection of the plant and of its products.

Verification inspection may consist of taking samples of products and plant records. Verification inspection procedures should carried out after the establishment of HACCP and other process control systems has been completed.

Facility rating and inspection frequency

It is the opinion of the researcher that there is a need for a relatively high frequency, in the near future, of inspection of establishments, by the regulatory authority in order to support, in particular, the persons responsible for the operation of HACCP. No exact figure can be given but no less than six times per year should be recommended for major establishments that product of products at a high risk level. However, this number of inspections might be appropriate, as well, for those establishments with production at a lower risk level. .

The financing of inspection is a problematic issue. There are several possible ways to cover the cost of the inspections. One is to let those who benefit from the inspection, namely the consumers, pay. Other possibilities are to put the burden on the establishment requiring payment, based on production tonnage, and hourly inspection fees. The latter could be implemented by classification of plants' inspection frequency. Inspection taxes should be charged, based on that inspection frequency. For example, a plant classified as "A" would pay less than a plant classified as "B" and so on (see Table 5.1). In addition, industries classified as "A" would be able to use stamps of quality on their labelling, for example.

Table 5.1 HACCP systems audit frequency schedule processing establishments

Frequency rating	Systems audit frequency	Qualifying visits for next higher level
A	Once every 6-month	NA
B	Once every 2-months	3
C	Once every month	2
D	Once every two weeks	2
E	Daily	NA

Certification of HACCP systems

In the light of the mandatory requirement for the application of HACCP by some countries for specific food products, food exporters in Oman (particularly the fishery industry) need to apply HACCP systems or risk the possible loss of market access. In addition, many countries (e.g., EU and U.S.A) require food exporters to provide certification that the HACCP plan is effective in meeting food safety objectives of the importing country. HACCP can be certified by an official competent authority or a recognized independent third party. It is anticipated that the certification process would validate the effectiveness of the HACCP plan and provide verification of compliance of the HACCP system with the HACCP plan. Certification should also involve confirmation that the industry has an overall quality assurance system that provides the appropriate hygiene controls to ensure that all food quality and safety requirements are met.

In Oman, the regulatory authority could certify companies according to the following procedure: Applications for HACCP certification are made to the regulatory authority. Once agreed, the two parties set a date for the audit. Each audit should be performed by a team of auditors. Prior to this, the regulatory authority should perform an adequacy audit based on the written submission of the company's HACCP document including the HACCP plan. The company should be alerted to inadequacies before the audit visit. The auditors should make preparation for the audit, including the checklist and corrective action request forms (see Appendix V).

The audit proper should consist of the entry meeting, going through the documentation and updates, making a round of observation of the actual processing, checking all HACCP related records, and concluding with the exit meeting, where corrective action request forms are issued, accepted by the company and signed. The HACCP audit report should be completed as soon as the auditors have received an indication of the dates when the corrections should be completed. A copy of the report should be sent to the regulatory authority for their records, and a copy should sent to the company.

A follow-up audit should be performed after all corrective actions have been implemented. The auditor should recommend to the regulatory authority to issue the HACCP certificate if the follow-up audit is satisfactory. The certificate should be valid for a period of time (for instance, one year). The regulatory authority should carry out verification (surveillance audit) at a predetermined frequency, based on the recommendation of the auditors. Criteria for certification can include:

- licensed by Local Authority for operation;
- registered with the registrar of companies;
- in place effective prerequisite programmes;
- HACCP documents:
- company profile;
- management commitment to safety policy and objectives, endorsement;
- HACCP team members qualification and job specification;
- HACCP certification;
- product description and intended use;
- plant layout indicating process flow;
- flow diagram including on-site verification;
- hazard analysis worksheet;
- the seven principles HACCP plan;
- prerequisite programmes (GMP, hygiene and sanitation), and
- training policy.
- HACCP system must have been implemented;
- product for domestic market must comply with Omani regulatory requirement, and
- product for export must comply with importing country's requirement.

Steering group

In Oman, the regulatory authority has to consider that different approaches to HACCP might be developed, by different food industries which might result in confusion. On the other hand, there is no one HACCP programme that fits all. Regulatory requirements need to be clearly communicated to industry and regulators need to consult with and listen to feedback from all stakeholders, as each HACCP application is unique. To address these issues a national HACCP steering group should be established consisting of representatives from both the regulatory authorities and the various food industries. The aims of the group would encompass the following areas:

- promote a uniform approach to HACCP development and implementation;
- promotion of a common approach for the identification of hazards, critical control points (CCPS) and critical limits;
- provide initiatives for making HACCP work;
- determine appropriate training requirements for different knowledge levels;
- develop a guide to effective auditing of HACCP plans;
- clarify the role of regulatory authorities with regard to HACCP, and
- promotion of understanding and awareness of food safety practices through education;

5.4.4. Establishing a quality control policy for export

The exportation and importation of food is big business and could be, for many exporting countries, a major source of foreign exchange (Baptist, 1989). If unscrupulous dealers export unfit food items, not only will that country's name be tarnished on the international market, but also it could lead to a huge loss in foreign exchange earning to the country.

Oman should carefully determine its priorities in establishing a strategy for utilizing its national, and often scarce, resources. Where, as in the case of Oman, few resources are available, the task becomes more difficult, and it is necessary to decide how to get the maximum return from each unit of resource invested.

Today, many food importing countries are adopting the attitude that more responsibility should be taken by exporting countries to ensure that their products, for which they receive the profits, are safe, are of an acceptable standard and meet the mandatory import requirements. The result is that certification as to compliance from exporting countries is being increasingly sought by importing countries with a hardening of attitude when certification is found to be unreliable and products unacceptable. The situation has been reached where food exporting countries cannot afford to be without some sort of "Export Quality Control System (EQCS)" which can at least provide the mandatory certification required by importing countries. Therefore, the establishment and administration of an EQCS is more needed than ever. Nevertheless, the decision to establish an EQCS should not be taken lightly. The decision should stem from a strong political conviction and a genuine desire to compete successfully with other exporting countries in international markets. To achieve this, it is necessary to export only those foods that are safe and will not threaten the health of the consumer; conform with established standards; at least compare favourably in quality with similar foods marketed by competitors; and most importantly, comply with the mandatory requirements of importing countries.

In addition, Oman might use EQCS to prevent avoidable losses of foods during processing, transport, storage and handling; to achieve improvement in quality of its food products; to encourage and facilitate an orderly development of its food industry and associated trade. EQCS can be operated by limit its activities to ensuring export products meet the requirements of importing countries, or used to assist exporters by monitoring importer specifications and providing certification that those specifications have been met by the exporter.

5.5. Conclusion

The objectives of the Omani food safety system can be analysed by examining how it currently performs. A basic criticism of the present system of food control is that it largely confines itself to registering food products and establishments. In contrast, it carries out very few activities involving preventive inspection or education. Frequently, a number of different agencies have responsibilities for aspects of food safety and quality. Lack of coherence among different governmental activities concerning agriculture, food, fish, trade, industry and health does not achieve optimal results. For example, there is an overlap of enforcement activities between the MAF, the Ministry of Regional Municipalities and Muscat Municipality. This often results in duplication of effort, waste of time and money and confusion. Significant opportunities may exist for sharing of expertise, inspection resources, laboratory facilities and administrative support. This is important from the perspective of optimal utilization of limited expertise and resources.

Overall, there is a lack of implementation of the basic elements necessary for an effective national strategy for control of health and hygiene standards for food production in Oman. For example, the Ministry of Agriculture and Fisheries (MAF) has begun a programme to implement HACCP for fish, only. It has given top priority to implementation for companies involved in export. This highlights the fact that Omani food safety policies are currently more influenced by the requirements of international trade than by domestic public health concerns. Moreover, the MAF itself recognizes the fact that, although the country intends to fulfil its external commercial commitments, it often fails to enforce importation requirements due to a lack of adequate legislation and institutional inefficiency.

The concern of multiple government agencies with the enforcement of provisions of food laws often results in parallel directions or overlapping regulations, and sometimes leads to confusion. The system of sanctions when food laws have been violated is ineffective, as few fines are assessed, the values are low, and judicial processes are extremely slow. Data to evaluate the effectiveness of the enforcement system for health standards are scarce. In addition, enabling regulations necessary for the enforcement of such laws should be enacted since, without them, the future of food control may be jeopardised. For example, data are not available on enforcement actions taken and their results. Data on morbidity and mortality related to illnesses of foodborne origin are inaccessible because they have not been documented or computerised. In addition, the absence of data on composition of local or indigenous food makes the development of food standards difficult and affects the whole concept of food control. There, is therefore, an urgent need to determine the composition of local foods in order to enforce regulations on standards.

The absence of skilled or trained personnel in all disciplines or the food control service is one factor that particularly hinders the development of an effective food control system in Oman. This is particularly clear in the area of personnel for the laboratory analysis for chemical and microbiological testing of foods. The number of skilled personnel employed is small in relation to the responsibility expected of them. Food processing activities in both urban and rural areas have grown tremendously in the past decade, such that the few trained personnel available can no longer cope with them.

Chapter Six

Research Methodology

6.1. Introduction

This chapter describes the procedures used to collect the data relevant to the study. Research designs provide many functions: they provide the researcher with a blueprint for studying social questions; they dictate the boundaries of the research activity and enable the investigator to channel his energies in specific directions; and they enable him to anticipate potential problems during the implementation stage (Black and Champion, 1976). This chapter introduces the rationale for the selection of the data-collection methods. Then an account is given of the survey population and the procedures implemented to select the study sample. A description is also provided of the techniques used for data collection and implementation. The final section describes the statistical techniques used in the analysis of the data. A detailed analysis of the linkage between the research questionnaire and Directive 91/493/EEC and Decision 94/356/EEC is included in Appendix X.

6.2. Selection of the methodology

The rationale for the selection of the method depends on the research questions and the setting of the study area. The aim of this study is to explore the process of HACCP implementation in the Omani food sector, using the seafood processing sector as a case study. The objectives are: to establish the level of implementation of HACCP systems, to obtain information on the industry's hazard awareness and to establish the barriers to HACCP implementation.

The seafood processing sector is selected as the case study for two main reasons: firstly, because it is one of the first sectors within the Oman food processing industry that is subject to a legal requirement (Council Directive No. 91/493/EEC) to implement an own-checks-based food safety control system for export (see Chapter Three and Appendix IX for an account of how the demands of Directive 91/493/EEC have come to include HACCP implementation), and secondly, because of the commodity-type nature of many seafood products, and therefore the similarity of the manufacturing system between different processors, which makes it easier to discern and compare the process by which HACCP is implemented. Whilst the results of the survey are clearly specific to the seafood processing sector, the researcher hopes that they will provide information which is more widely applicable to the food processing sector as a whole.

Individual fish processing strategies of the companies must be investigated. Thus, individual fish processing companies were selected as the unit of analysis in this study. It is guided in this by Babbie (1975) who defines the unit of analysis as the people or objects whose individual characteristics are aggregated for the purpose of describing some large group.

The past three decades have seen a growing recognition of the need for a research methodology exploring multiple data sources. The weaknesses of individual methods can be overcome or reduced by merging two or more methods of data collection together to produce more meaningful results. In general, the advantage of utilising information from separate data sources depends on the purpose of the research and the feasibility of obtaining the additional information sought (Warwick, 1983).

There are various research methods for data collection; for example, questionnaires, in-depth interviews and observation all of which can be employed in research method to collect information about the target population. Survey methods are more appropriate in cases where quantitative data are required and when the information sought is specific and familiar to respondents (Bulmer and Warwick, 1983), a description which is generally applicable to the present study.

To carry out this study, a questionnaire was employed as the main method of data collection. The researcher, however, decided that a questionnaire alone would not fulfil the purpose of this study, so a decision was made to supplement the questionnaire by; (a) semi-structured interviews of key-informants and (b) a checklist of the existing practices of fish handling, processing, plant layout, level of sensitisation and hygiene level (i.e., Good Manufacturing Practice), as well as HACCP documentation and procedures inside the plants. The three methods enabled different types of data, to be collected. Such use of multi-methods gives the researcher more confidence concerning his conclusions than he would have if he had employed a single method (Whyte and Alberti, 1983).

6.3. Designing the sample

The design of a sample depends on the research objectives. As stated by Arber, "some researchers select samples in order to provide the maximum theoretical understanding, while others are primarily concerned to obtain a representative sample so that they can make inferences about the whole population" (Arber, 1993, p. 86). The concern of this study was to select samples in order to provide the maximum theoretical understanding. There are 39 fish processors in Oman, of which 22 claimed to apply a HACCP system in their operations. These are large companies, in terms of to both number of employees and gross income. Therefore, in carrying out this study, it was considered appropriate and feasible to interview all of the fish processors.

The sampling frame used for selecting the panel was a list provided by Ministry of Agriculture and Fisheries, which provided information about the each processors address, location, operation type, volume of production etc.

6.4. The Questionnaires

To operationalize the general concepts of this study the researcher employed a questionnaire as the main method of data collection. Babbie defines operationalization as the process through which the researcher devises procedures and operations that will result in observations relevant to general concepts he is interested in studying (Babbie, 1975; p. 105). The questionnaire is a very widely used tool of operationalization in which concepts are given shape in the form of questions, which are then put to the people under study: In this case a questionnaire was administered to two persons in each fish plant. The two persons were those considered by the researcher to exert most direct influence on the safety of operations and quality. The fish business manager and the quality controller were generally the two staff members interviewed. An administered questionnaire format was selected to enhance the completion rate, reduce the number of unanswered questions, and enable probing and controlled clarification (Babbie, 1975; p. 275). Respondents were assured that the results from individual companies and persons would remain confidential to encourage more a open response to the questions posed, except where information, such as selected data from the state-owned Omani Fisheries Company, were already in the public domain.

The aim of this study is to explore the process of HACCP implementation in the Omani fish industry. The HACCP methodology is based on the procedures adopted by the US National Advisory Committee on Microbiological Criteria for Foods (1992), Codex Alimentarius (1993) . HACCP has also come to be incorporated formally, by name, into the EU legal system in the horizontal food hygiene Directive 93/43/EEC. Commission Decision 94/356/EC elaborates the detailed practical implications of Directive 91/493/EEC, and requires the implementation of HACCP systems in establishments in all but name. Appendix X sets out the correspondences between Council Directive 91/493/EEC, Commission Decision 94/356/EC and the questionnaire.

To achieve accuracy in obtaining the data, the questionnaire schedule was divided into three sections and used a mixture of closed questions, open questions and attitudinal scales. The first section of the questionnaire concerns general information about plant size production in tonnes/year, and about the education level and experience of both the fish business manager and the quality controller (i.e. the company's profile). The second section deals with prerequisite programmes, as these are the cornerstones for HACCP implementation. The third section concerns the establishment and implementation HACCP. Under this section, there are a number of questions used to elicit information about the business's motivation for HACCP implementation. This section also concerns opinions about the current status of the HACCP system. It aimed to elicit respondents' opinions and record their responses. Three attitudinal scales are included in this section to measure operator attitudes.

The questionnaire contains two categories of questions. The first type is factual questions to obtain objective information from the respondents regarding their backgrounds, knowledge and their operation. The second category of questions concerns the respondents' attitudes towards the HACCP system. Attitudes are defined as general orientations that can motivate a person to act or react in a certain manner when confronted with certain stimuli (Nachmias and Nachmias, 1996; p. 252). Attitude is normally measured by more than one question, because, unlike factual questions, respondents may not have an attitude toward the concept and because many attitudes have numerous aspects the respondent may agree with one aspect and disagree with another. As stated by Nachmias and Nachmias (1996), "by using several attitude statements, a researcher can more accurately ascertain both the strength of a respondent's attitude and the conditions under which his or her attitude may change".

The respondents' opinion about whether HACCP is a more effective safety control strategy than other methods used for ensuring food safety, whether HACCP can be used as a defence of due diligence, whether HACCP is an expensive system, whether a HACCP system can generate benefits if applied in operations and whether HACCP is a time consuming system vis-à-vis the end benefit of its implementation, were measured using attitude scales consisting of three attitude statements, to which respondents were asked to indicate their degree of agreement or disagreement. This approach to measurement, called a summated scale, was devised by Likert (1932), and is the most widely used approach to measurement in the social sciences today[1]. Many Likert-type scales use a 5-point response composed of (1) strongly agree, (2) agree, (3) undecided, (4) disagree, and (5) strongly disagree. Adams and Schvaneveldt (1991; p. 160) state

[1] Another method of scaling is the Guttman scaling technique developed in early 1940s by Louis Guttman. A Guttman scale is unidimensional as well as cumulative, in that information on the position of any respondent's last positive response allows the researcher to predict all of that person's responses to the other items (Nachmias and Nachmias, 1996; p. 474).

that fewer or more response categories have been used. In this study, a three-point scale was employed, to avoid any confusion to the respondents; the researcher felt that using five response categories in the scale would confuse the respondents and may possibly produce some bias in the results. This is because it is difficult to differentiate between "strongly agree" and "agree". This was confirmed during the pilot study when the researcher observed that a five point scale made respondents confused and the researcher found it difficult to record accurately respondents' reaction to the items of the scale. A decision was made at this stage to reduce the scale response categories from five points to three points, namely, (1) agree, (2) undecided, (3) disagree.

In the following sections, the content of the three sections of the questionnaire is discussed in more detail.

6.4.1. Section one: Company profile

Five questions were included in this section (see Table 6.1). The aim was to quantify companies regarding their volume of production, number of people working with them and the length of experience and level of education of the staff.

Table 6.1. Company structure

Statement
1. Please tick the number that best describes your total volume of business (metric tonnes/year) for fish production and processing in 1999 • Less than 10,000 • Between 10,000 and 20,000 • Between 20,000 and 30,000 • Greater than 30,000
2. Fish business manager, length of service in the fish industry • Under 10 years • 10 - 19 years • + 20 years
3. Quality control's length of service in the fish industry • 1 - 4 years • 5 - 10 years • 11- 15 years • 16 - 20 years
4. Quality control level of food hygiene training • Certificate • Training • No training
5. Number of staff employed • Full-time • Part-time

6.4.2. Section two: prerequisite programme

Prerequisite programmes include elements previously, and still frequently, described as GMP (e.g., cleaning, operator and environmental hygiene, plant and building design and preventive maintenance- see Chapter Two). These concepts have been employed by the food industry for many years. The concept of GMP has long been considered as a support programme that provides foundations for HACCP in an overall food safety management programme (Sprenger, 1995).

To carry conviction, the programme should be documented. Under it each processor is required to carry out checks to ensure that the programme is being followed. Five essential areas (i.e., cleaning, hygiene and sanitation procedure, monitoring and record keeping, food storage, cross contamination and temperature control, personal hygiene principles and practices, and food hygiene training) were investigated in this study.

Cleaning, hygiene and sanitation procedure

A cleaning procedure or programme is part of GMP, and thus is considered a prerequisite within any food processing environment. However, cleaning procedures may also be considered as part of the main HACCP plan (see Chapter Two, paragraph 2.4.2.), which is often critical in preventing serious microbiological contamination.

Table 6.2. Cleaning, hygiene and sanitation procedure

	Statement
1.	Do you have a cleaning schedule? • Yes • No
2.	Is your cleaning schedule documented? • Yes • No
3.	Which of the following is best for cleaning and disinfecting the inside of refrigerator/freezer/cold storage? • Sodium bicarbonate • Vinegar solution • Bleach solution • Odour-free bactericidal detergent
4.	Which of the following is considered to be a good food contact surface sanitizer? • Iodine • Quaternary Ammonia • Chlorine • Phenol

Monitoring and record keeping

The questions which were posed to the respondents, as shown in Table 6.3, aimed to investigate the extent of compliance with HACCP implementation in terms of checking raw materials, monitoring the temperature of food products at different stages or steps in processing, and investigating documentation in each processing step (HACCP Principle 7).

Table 6.3. Monitoring and record keeping.

Statement
1. Do you check the raw materials/ingredients for safety on receipt from your suppliers? • Yes • No
2. Do you take samples of the raw materials for microbial examination? • Yes • No
3. Are records of these tests kept? • Yes • No
4. Do you monitor temperature of food/fish at any stage in your operation? • Yes • No
5. Do you keep records of temperature? • Yes • No
6. At which of the following stages do you monitor temperature levels? • On receipt of foodstuff/fish and ingredients from suppliers • During cooking/processing • After cooking/freezing • During re-heating/cooling • During hot/cold holding/chilling/cold storage/freezing • During delivery • None of the above

Food storage, cross contamination and temperature control

Hygienic processing and preparation of food has, for many years, been regarded as a basic requirement and the first line of defence against pathogenic microorganisms. While this approach is unable to guarantee fish products free of the pathogens, good hygiene, cleaning, and sanitation are necessary to secure low levels of these organisms on the final product.

This section of the questionnaire aimed to assess the respondents' knowledge about food storage, cross contamination and temperature control procedures. In particular, these questions were designed to assess the respondents' knowledge of preventive measures against food poisoning, common causes of food contamination, safety systems for storage and handling of food, and the practical application of temperature control in food processing and storage (Table 6.4).

Table 6.4. Food storage, cross contamination and temperature control

	Statement
1.	All food products must be stored at least ____above the ground • 15 cm • 20 cm • 30 cm • 45 cm
2.	If only one refrigerator is available, which of these would you advise? • To store cooked food above raw food • To store raw food above cooked food • To store only raw food in the refrigerator • To store only cooked food in the refrigerator
3.	During which of these occasions can cross contamination of food occur? • When one infected food handler spreads the infection to other food handlers • When bacteria is transferred from raw to cooked food • When bacteria is transferred from cooked to raw food • When rodents and insects transfer from one premises to another
4.	Why it is necessary to cool hot foods before refrigeration? • To make cooling faster • To prevent raising temperature of already stored food • To prevent cross contamination
5.	At which of the following temperature levels will most food-poisoning bacteria multiply? • -18° C to - 0 ° C • 0 ° C to 20 ° C • 20 ° C to 50 ° C • 5 ° C to 63 ° C
6.	The food safety danger zone is.... • 0 °C to 10 °C • 10 °C to 20 °C • 10 °C to 55 °C • 5 °C to 63 °C
7.	What is the correct operating temperature of a refrigerator? • -18° C to -22 ° C • 1 ° C to 5 ° C • 12 ° C to 18 ° C
8.	According to food safety principles, a freezer unit's temperature should be • Cooler than -18 °C • Cooler than -5 °C • At 0 °C • Less than 8 °C

Personal hygiene principles and practices

Respondents were asked specific questions to assess their knowledge of hygiene principles and practices (Table 6.5) in terms of standards of personal hygiene for food handlers, potential dangers associated with the handling of food by carriers or cases of food poisoning or foodborne infections.

Table 6.5. Personal hygiene principles and practices.

	Statement
1.	Which of the following is a food safety rule of personal hygiene?
	• Open cuts or wounds should not be covered by dressings
	• Clear fingernail polish is all right
	• It is all right to use a toothpick while working
	• You should wear no jewellery while you work
2.	Smoking by food handlers in food handling area is to be discouraged because
	• Food might absorb smoke flavours
	• Smokers tend to cough over food
	• Smokers touch their mouths with their fingers

Food safety training

The three questions in this section aimed to find information about level of food safety and hygiene training, training in the HACCP system (Table 6.6).

Table 6.6. Food safety training.

	Statement
1.	How many of the staff have the basic food hygiene certificate?
	• Full-time
	• Part-time
2.	Is staff training documented?
	• Yes
	• No
3.	Do you have a training policy?
	• Yes
	• No
4.	If yes, what is this policy?

Customer complaints

This section aim to assess both the awareness of customers and the company compliance with the system by keeping a complaint logbook.

Table 6.7. Customer complaints

	Statement
1.	Do you sometimes receive complaints from your customers? • Yes • No
2.	Do you have a complaint logbook • Yes • No

Seeking help on food hygiene matters

It is important to build a channel between the regulatory authority and the industry. Therefore, this question investigates how far the relationship exists.

Table 6.8. Seeking help on food hygiene matters

	Statement
1.	Have you ever approached the inspection authority for advice on issues related to food safety? • Yes • No

Inspection

Although this was not intended to generate data on its own, it was vital in eliciting information on the adequacy of premises, and the degree of documentation, as well as on the verification of records.

Table 6.9. Inspection

Statement
1. How long is it since the inspection authority officer visited your food business premises?
2. What was the outcome of the visit? • Oral improvement notice given • Approval without conditions • Conditional approval • Written notice served • Other
3. What was (were) the nature of the issue(s) raised during the inspection? • Structural • Procedural

6.4.3. Section three: Establishing HACCP system

This section consisted of two parts. Part one investigated a knowledge of hazard analysis as the first principle to implement HACCP system, while the second part was concerned with HACCP implementation and procedure.

Hazard analysis

This section include questions about hazard awareness. It consisted of three items of a self-administered type with mainly multiple-choice answers; see Table 6.10.

This section aimed to assess participants' awareness of associated seafood hazards. A number of questions were asked on factors influencing the epidemiology of foodborne diseases, including microorganisms and factors affecting their survival and multiplication in foods as well as identify the problems associated with food pests such as rodents, birds and insects (see Table 6.10). The respondents were asked to indicate those they were aware of, and those they were not familiar with. Four pathogenic microorganisms (*Salmonella, Clostridium perfringens, Staphylococcus aureus,* *Clostridium botulinum*) and one chemical pathogen (Histamine) were selected that are characteristically associated with seafood hazards (Huss, 1994). Their control should be considered critical. The important characteristics of these bacterial agents are discussed in more details in Chapter Two.

Table 6.10. Food poisoning and foodborne infections

Statement		
1. Food poisoning bacteria can be passed on from • Wild birds • Rodents • Insects • All of the above		
2. Which of the following terms have you heard of? (Please tick (√) in the appropriate space)	Heard of	Not heard of
Salmonella	______	______
Clostridium perfringens	______	______
Staphylococcus aureus	______	______
Clostridium botulinum	______	______
Histamine	______	______
3. Which of the following do you think is most likely to be spread by coughing and sneezing? • *Salmonella* • *Clostridium perfringens* • *Spores* • *Staphylococcus aureus* • *Vibrio cholera*		

HACCP plan

The general aim in this part was to determine which parameters might interfere in the implementation of the HACCP system. This was done by investigating (a) the companies' incentive to implement HACCP, (b) availability of HACCP plans, (c) implementation procedures preferred by fish processing operators, (d) cost of HACCP implementation and (e) time of HACCP implementation.

Table 6.11. Establishing HACCP system

	Statement
1.	Which of the components of International Standards Organisation (ISO9000) System have you introduced in your company? • ISO 9000 • ISO 9001 • ISO 9002 • ISO 9003 • None of the above
2.	Have you received any information on HACCP? • Yes • No
3.	Where from? • Scientific journals • Through collaboration with academic institutions or Ministry of Agriculture and Fisheries • External consultants • Export needs
4.	Do you have a HACCP plan for your business now? • Yes • No
5.	If yes, how was it prepared? • Prepared solely by private consultant(s) • Prepared in-house with the assistance of private consultant(s) • Prepared in-house with guidance of the authority • Prepared in-house without external assistance • Other
6.	If No, do you intended to have one? • Yes • No • Not decided
7.	Why are you implementing a HACCP system? • European Council Directive No. 91/493/EEC requirements • Quality assurance improvement • Use HACCP as a marketing tool for market development
8.	Are you adequately staffed to implement HACCP at present? • Yes • No • I do not know
9.	If No, what staff are needed? Specify____
10.	What is the most preferred HACCP training approach? • Participation in the development of a HACCP plan • Videotapes teaching HACCP plan • Group discussion • Workshops • Information from regulatory officials
11.	If HACCP implementation is made mandatory, what implementation procedure would you prefer? • Ready to prepare and submit own HACCP plan for approval by the regulatory authority • Would require assistance in identification of CCPs, development of monitoring and evaluation procedures, and preparing own plan
12.	Which of the following contributes the major cost in implementing HACCP in your operation (*Please rank, in order of high cost, 1 = highest costs to 8 = lowest costs from 1 to 8*) • Developing HACCP Plan ______ • Consultants fees ______ • Training costs ______ • Hiring new employees ______ • Sanitation costs ______ • Laboratory analysis ______

Count. Table 6.11

- New equipment ______
- Plant modification and construction ______

11. How long it takes to make the HACCP system to be settle-down in your operation.
    - 3 to 6 month
    - 6 to 12 month
    - 1 to 2 years
    - more than 2 years

Opinion and attitudes towards HACCP system

Several questions were put to companies about their opinions on the HACCP system, and their attitudes towards the likely impact of the system's implementation in their day-to-day operations. See Table 6.12.

Table 6.12: Opinion and attitudes on HACCP system

Statement
1. HACCP is a more effective safety control strategy than your current method or other method(s) you have used for ensuring food safety. • Agree • Undecided • Disagree
2. HACCP can be used to support a defence of due diligence • Agree • Undecided • Disagree
3. HACCP is an expensive strategy • Agree • Undecided • Disagree
4. The HACCP system can be beneficial to my operation(s) • Agree • Undecided • Disagree
5. HACCP is a time consuming strategy vis-à-vis the end benefit of its implementation • Agree • Undecided • Disagree

6.5. Validity

"Validity refers to the degree to which an instrument measures what it is supposed to be measuring" (Polit and Hunger 1999, p. 418). The scales used in this study were intended to measure different concepts of HACCP implementation. The items in these scales measure the concepts from different dimensions and therefore these measurements are indirect. In this circumstance it is not certain that they are measuring the variable for which they were designed. Hence, supporting evidence is needed to prove that a scale is measuring what it appears to measure. This supporting evidence is obtained by testing the validity of the scale, which is a measure of the scale's adequacy and accuracy.

The methodological literature abounds with terms relating to different facets of the validity question. According to Litwin (1995) there are several types of validity, which are typically measured when assessing the performance of a survey instrument: face, content, criterion and construct. Criterion and construct validity are difficult to measure because the former needs to be judged against some other method, known as a "gold standard", for assessing the same concept, and the latter is determined only after years of experience with the instrument. Polit and Hunger (1999, p. 419) state, "One requirement of the criterion-related approach to validation is the availability of a reasonably reliable and valid criterion with which the measures on the target instrument can be compared. This is, unfortunately seldom easy". As there is no known "gold standard" for the scales used in this study, which could be used to determine the criterion validity, the researcher had to settle for testing the face and content validity of the scales.

6.5.1. Face validity

Face validity refers to whether the instrument looks as though it is measuring the appropriate construct. At the very minimum, a researcher who develops a new measure should establish that it has face validity-that is, that the measure apparently reflects the content of the concept in question (Bryman and Cramer, 1997). The researcher took the following steps to make sure that the questionnaires have high face validity.

The questionnaires were reviewed thoroughly by the researcher and his supervisor to check on the clarity of the questions and their appropriateness to fish operators in Oman and to ensure that the meaning reflects the content of the scales. Therefore, many changes and modifications were made to the original versions of the questionnaires.

The questionnaires were also shown to friends and colleagues at the University of Hull who are familiar with the questionnaire topics. Their comments were considered and some of the questions and statements were modified accordingly.

6.5.2. Content validity

Content validity is concerned with the sampling adequacy of items for the construct that is being measured. The content validity of an instrument is necessarily based on judgement. There are no completely objective methods of ensuring the adequate content coverage of an instrument. However, it is becoming increasingly common to use a panel of experts in the content area to evaluate and document the, content validity of instruments. The content validity of the questionnaires of this study was reviewed by a panel of experts in both the Institute of Food Health Quality at the University of Hull and the College of Agriculture, Sultan Qaboos University (Oman). Two key issues were taken into account: whether individual items were relevant and appropriate in terms of the constructs and whether the items adequately measured all dimensions of the construct.

6.6. Pilot study

An initial reading of existing literature made clear the importance of a pilot study, based on the argument of Hoinville and Jowell (1978, p. 90): "The creation of a good questionnaire does not have to rely solely on the researcher's perspective. At some stage in the design process the questionnaire should be subjected to a field test."

The importance of pilot testing has been emphasised by many writers such as Borg and Gall (1983), Hayman (1968), Cohen and Manion (1985), Lin (1976), Johnson (1977), and Ary et al. (1972). Although all the foregoing writers proclaim the importance of the pilot test, it might be valuable to indicate the reason for this importance.

Borg and Gall (1983, 30-31) reported, "Every questionnaire must be tested and refined under real world conditions. Even after years of experience, no expert can write a perfect questionnaire". The pilot test is very important in a research investigation because it helps the researcher to see how the questionnaires will be conducted at the time of the main study and how long respondents take to complete them, and to locate any ambiguities. On this basis, researchers can remove any items which do not yield usable data, add items to fill any data gaps and reword unclear questions, in preparation for the main study.

The first draft of the questionnaire was tested on a few fish operators in the Capital area (Muscat) to make sure that all the questions were clear and to measure the time required for each interview. The researcher discussed the questionnaires with fish operators question by question and statement by statement, to ensure that the questions were understandable, appropriate, and relevant to the measured scales. The first draft contained 80 questions and the average completion time for each respondent was 45 minutes. The results of the pilot study indicated that the questionnaire was too long and respondents became bored after about 30 minutes of interviewing. Hence, the researcher reduced the number of questions and the questionnaires were tested again. The pilot study, together with consultation with experts in the field, resulted in a number of refinements and alterations being incorporated into the final form of the questionnaire, which was used for the present study (Appendix I).

6.7. Procedures and implementation of the questionnaires

Prior to the start of the actual study, the researcher visited some fish processors and had informal talks with some fish operators, explaining to them his objectives and the importance of the study. Official letters from Ministry of Agriculture and Fisheries (the researcher's employer) were prepared to facilitate the work of the researcher. All this contributed to raise fish operators' awareness of the importance of this study, which was essential for the success of this work.

The researcher himself carried out all interviews. The process was conducted on a face to face basis and normally took place in fish processing plants. Field visits started early in the morning at 6.00 a.m. and extended until 5.00 p.m.

Fieldwork began on 10th June 2000 and finished on 20th November 2000. A total of 40[2] fish business managers and quality controllers were interviewed.

[2] There are 39 fish processors in Oman, of which 22 claimed to apply a HACCP system in their operations. These are large companies, in terms of to both number of employees and gross income. Therefore, in carrying out this study, it was considered appropriate and feasible to interview all of the fish processors.

6.8. The semi-structured interview

Nachmias and Nachmias (1996) define an interview as a face to face interpersonal role situation in which an interviewer asks the respondent questions designed to elicit answers pertinent to the research hypotheses. In the section above, the questionnaire survey, which was the main method of data collection in this study, was described. A drawback of the questionnaire survey is its lack of flexibility, since the number of questions and wording of the questions are the same for all respondents. In this case, the interviewer must ask questions in the same sequence in every interview and the researcher cannot probe to obtain more information. More flexibility in interviewing can be found in semi-structured in-depth interviews. Semi-structured interviews were therefore used as a second method of data collection. In this type of interview, the interviewer does not need to use a schedule to ask a prepared set of questions. It is also not necessary to ask questions in the same sequence or wording in every interview (Fielding, 1993). In this type of interview, the researcher has a clear focus of inquiry in his mind, while he tactfully questions and actively listens to the respondent. The interviewer asks questions pertinent to the study as each opportunity arises, then listens closely to responses for clues as to what question to ask next (Maykut and Morehouse, 1994).

Semi-structured interviews were carried out to add to the richness of the quantitative data obtained by the questionnaires, by providing qualitative data to support the research findings and to validate the results. This method is very flexible, as respondents can be encouraged to talk about the topic of interest from their own perspective. The role of the researcher in semi-structured interviews is as a mediator to direct and control the interview. The researcher probes for more information when he feels that, at a particular point during the course of the interview, there is a gap in information, which needs to be filled. In this study the interview was an exploration of all aspects of fish processing likely to impinge upon food safety both on-site and off-site. In particular, it was an attempt to establish the level of food safety awareness and the degree to which food safety was being pursued through the HACCP system.

The researcher developed an interview guide containing a list of topics which were not covered by the questionnaires or needed more elaboration to support the evidence (Appendix II). The topics focused on the company's situation before they implemented the HACCP system, situations encountered during the implementation of the HACCP system, and the situation after HACCP implementation.

6.8.1. The interview sample

The selection of interviewees was based on their long involvement in fish processing. Twenty interviews were conducted immediately after the completion of the questionnaire survey (November 2000). The researcher carried out all interviews and they were tape recorded and then transcribed immediately. It is recommended to transcribe the interview soon after it has occurred, while it is still fresh in the interviewer's mind (Maykut and Morehouse, 1994; p. 100).

All interviews were carried out at the key informants' plants. The researcher visited the key informant and after introducing himself he explained the objectives of the research and how the respondent had been selected for the interview. A letter from the Ministry of Agriculture and Fisheries and one from the University of Hull, permitting the researcher to carry out his study, were shown as well, to make the respondent more comfortable talking to the researcher. Permission to use a tape recorder was obtained before the start of the interview. The first topic asked was on the situation before HACCP implementation. The respondent then described the status of his company and the processing procedure which was followed.

6.9. Checklist of fish processing operation

The third method used to obtain data for the present study was a checklist, which combined well with the questionnaire survey and semi-structured interview, to overcome any limitation of either method. In addition, the checklist was employed to collect supplementary data for use in interpreting or qualifying findings obtained by other methods (see Appendix III). This method seemed to be most appropriate in relation to the questionnaire for a number of reasons. For example, most of the items required a confirmation of information given by fish business operators, and the examination of records of, for example, temperatures, monitoring procedures, cleaning schedules, and other matters relating to processes. Most importantly, visits to food premises in connection with the interview provided an opportunity for the collection of observational data. To understand, explain and predict the operators' daily activities in their plants, the researcher went into the field and checked their activities while they were receiving, handling, processing and storing the fish. The researcher's aim here was to obtain an insight into aspects of the demands of the on HACCP system and the level of sanitation of their facilities as it existed and which was practised in the day-to-day processing in each plant. The researcher visited all plants covered by the present study.

Plant checklists were based on forms used by FAO (FAO, 1994b) in assessing fish factories. The checklist was carried out at the same time as implementing the questionnaire survey. This helped the researcher to assess and evaluate how far the operators complied with the prerequisite programme.

The researcher observed the types of fish processing, landings and handling of fresh fish, and visited a number of fish markets and auctions to gain a general idea of the fisheries sector. Recording these daily activities helped the researcher to evaluate each plant, as well as to interpret the questionnaire and interview results.

6.10. Statistical analysis of the data

All the data were processed and analysed by using the Statistical Package for Social Science (SPSS), and the results are presented in the next chapter.

6.11. Conclusion

This chapter has explained the methods used to carry out the empirical survey to assess the HACCP implementation in fish companies in Oman. Triangulation was employed to collect and validate both qualitative and quantitative data. The data gathered in the survey through different collection techniques provided more accurate information and enabled description of several dimensions of operator practices. The main survey instrument was a questionnaire, designed to provide quantitative data. The questionnaire was supplemented by qualitative data derived from interviews with key informants and a checklist of the daily activities of the target population. The interviews and observations were useful in understanding the actual field situation and the issues that were not covered by the main survey instrument. The three methods, therefore, offer different types of data, which fit well together. In this case the researcher has more confidence concerning his conclusions than he would have if he had employed a single method. In the next chapters, the researcher will present the findings derived from these data.

Chapter Seven

Results

7.1. Introduction

This chapter presents the results of the data collected to describe the study population of fish processing companies in Oman. The presentation includes a description of the companies' structure, the type, number and experience of the employees. A comparison is made, wherever possible, of their existing practice, knowledge of food handling, levels of hygiene, and attitudes toward the HACCP system. The chapter aims to give a picture of how far the HACCP system is adopted in the Omani fish processing industry, although, as noted in Chapter 6, the commercial details from individual companies and persons are not cited by name.

The results presented in this chapter are very important when trying to evaluate HACCP implementation in developing countries in general and in Oman in particular. A description of the general characteristics of the processing companies is presented in the following section. The results obtained here are used for further discussion in the following chapter.

7.2. Section one: Company profile

The study covered twenty-two fish processors from a total of thirty-nine fish processing companies existing in Oman. These are big companies with respect to both number of employees and gross income. Nineteen companies (86%) of the sample exhibited export activity while the remaining three distributed their products only within the Omani market. Twelve (55%) are located in the central region of Oman while ten (45%) are scattered in different regions. The characteristics of the fish processing companies that participated in this study are shown in Table 7.1.

The first section of the questionnaire yielded information on numbers and types of employees, their experience and level of education and level of food hygiene training. From these items the researcher was able to build up a picture of the administrative structure of fish processing in Oman.

Most fish companies consist of a manager, the person in charge of fish quality/assurance and working line employees. Ten (45%) of the fish business managers had served in the fish industry for less than ten years, twelve (55%) for more than ten years. Ten (45%) persons in charge of quality control had less than ten years experience in the fish industry, while twelve (55%) had more than ten years. Twelve (55%) of the persons in charge of quality control had been trained to certificate level or equivalent, eight (36%) had formal food hygiene training and two (9%) had no food hygiene training.

Table 7.1. General characteristics of respondents.

	Frequency	%
Fish manager's length of service in the fish industry		
• <10 years	10	45
• >10 years	12	55
Quality controller's length of service in the fish industry		
• <10 years	10	45
• >10 years	12	55
Quality controller's level of food hygiene		
• Certificate	12	55
• Training	8	36
• No-training	2	9
Number of staff employed		
• Full-time	587	
• Part-time	55	9

7.3. Section two: Prerequisite programme

Cleaning, hygiene and sanitation procedure

Seventy-three percent of the fish companies had some form of contract with one or more outside operator to contribute a service, while twenty-seven percent had none. The most frequently cited contract (fifty-nine percent) was for pest control. Forty-five percent of respondents contracted for equipment maintenance, forty-five percent for refrigeration/freezer maintenance and fourteen percent for other services. Documentation of action taken by contracting agencies was observed in thirteen operations (59%), while nine (41%) did not appear to keep such evidence. Nearly all fish establishments had cleaning schedules, which were documented in twenty (91%) premises.

When asked to identify the best substance to be used for cleaning and disinfecting, inside a refrigerator, freezer or cold store, fourteen (64%) of the respondents knew the answer, while eight (36%) did not (Table 7.2).

Only one (5%) of the respondents was able to identify the substance which is considered to be a good food contact surface sanitizer, while twenty-one (95%) failed to do so.

Table 7.2. Cleaning, hygiene and sanitation procedure

	Frequency	%
Do you have cleaning schedule		
• Yes	22	100
• No		
Is your cleaning schedule documented		
• Yes	20	91
• No	2	9
Which of the following is best for cleaning and disinfecting the inside of refrigerator/freezer/cold storage?		
• Sodium bicarbonate		
• Vinegar solution		
• Bleach solution		
• Odour-free bactericidal detergent	14	64
Which of the following is considered to be a good food contact surface sanitizer?		
• Iodine		
• Quaternary Ammonia	1	5
• Chlorine		
• Phenol		

Monitoring of received products

Twenty-one (95%) of the respondents claimed that foodstuffs and ingredients in their establishments were checked for safety and quality on receipt from their suppliers. No such checks were done in one of the establishments; see Table 7.3.

Twenty (91%) of the establishments claimed to undertake microbiological sampling of foodstuffs and ingredients on receipt, while two admitted that they did not perform this type of check. Documentation of these tests was kept by nineteen plants (86%), while three did not record the results.

Twenty-one (95%) of the establishments claimed that they monitored the temperature of fish at their operations, while one did not conduct such checks. Documentation of these tests was kept by all of the establishments, which performed the relevant checks (Table 7.3).

Regarding the questions at which stages the plants conduct temperature checking, all of the establishments stated that they monitored temperature on receipt of foodstuff and ingredients from suppliers (more than one answer was given by companies):

- sixteen (73%) during processing
- seven (32%) after freezing
- fourteen (64%) during cooling
- sixteen (73%) during cold hold/chilling/cold storage/freezing;
- none did so during delivery.

Table 7.3. Monitoring of received products

	Frequency	%
Do you check the raw materials/ingredients for safety on receipt from your suppliers?		
• Yes	21	95
• No	1	5
Do you take samples of the raw materials for microbial examination?		
• Yes	20	91
• No	2	9
Are records of these tests kept?		
• Yes	19	86
• No	3	14
Do you monitor temperature of food/fish at any stage in your operation?		
• Yes	21	95
• No	1	5
Do you keep records of temperature?		
• Yes	21	95
• No	1	5
At which of the following stages do you monitor temperature levels?		
• On receipt of fish and ingredients from suppliers	22	100
• During processing	16	73
• After freezing	7	32
• During cooling	14	64
• During cold holding/chilling/cold storage/freezing	16	73

Five (23%) fish operators knew that food products must be stored at least 45 cm above the ground, while seventeen (77%) lacked such knowledge (Table 7.4).

Regarding the question which investigated the correct place to store food if only one refrigerator is available, seven (32%) of the operators gave the correct answer, which is to store cooked food above raw product, and fifteen (68%)failed to do so.

Twelve (55%) of operators were able to recognise the occasions where cross contamination of food can occur, while ten (45%) were not.

Seven (32%) gave the reason why it is necessary to cool hot foods before refrigeration, while fifteen (68%) failed to do so.

Only one of the operators was able to identify the temperature levels, where most food poisoning bacteria can multiply and twenty-one (95%) could not.

On the question of identifying the temperature of the food safety danger zone, seventeen (77%) of respondents were able to identify the temperature level at which the greatest risk to food safety occurs.

The correct operating temperature of a refrigerator was one of the questions asked of the fish companies. Only ten (45%) of the respondents were able to identify the correct level of temperature, which is at "1 ° C to 5 ° C".

The respondents were also asked to identify the correct temperature level for a freezer unit, according to food safety principles. The correct answer was given by twenty-one (95%) of the respondents, while five percent gave the wrong one (Table 7.4).

Table 7.4. Knowledge of, opinion about, food storage, cross contamination and temperature control

	% Correct	% Incorrect
All food products must be stored at least ____above the ground		
• 15 cm		
• 20 cm		
• 30 cm		
• 45 cm	23	77
If only one refrigerator is available, which of these would you advise?		
• Store cooked product above raw food	32	68
• Store raw product above cooked product		
• Store only raw product		
• Store cooked product in refrigerator		
During which of these occasions can cross contamination of food occur?		
• When one infected food handler spreads the infection to others		
• When bacteria transfer from raw to cooked food	55	45
• When bacteria transfer from cooked food to raw food		
• When rodents and insects transfer from one premises to another		
Why it is necessary to cool hot foods before refrigeration?		
• To make cooling faster	32	68
• To prevent raising temperature of already stored food		
• To prevent cross contamination		
At which of the following temperature levels will most food-poisoning bacteria multiply?		
• 18 to - 0 °C		
• 0 to 20 °C		
• 20 to 50 °C	5	95
• 5 to 63 °C		
The food safety danger zone is....		
• 0 to 10 °C		
• 10 to 20 °C		
• 10 to 55 °C		
• 5 to 63 °C	23	77
What is the correct operating temperature of refrigerator?		
• -18 to 22 °C .		
• 1 to 5 °C	45	55
• 12 to18 °C		
According to food safety principles, a freezer unit's temperature should be _____		
• Cooler than -18 °C		
• Cooler than -5	95	5
• °C At 0 °C		
• Less than 8 °C		

Personal hygiene principles and practices

The respondents were asked to identify a food safety rule in personal hygiene. Eighteen (82%) could correctly do so, while four (18%) could not (see Table 7.5).

On the question about the reason why smoking by food handlers in the food handling area is discouraged, half of the respondents were able to give the correct answer, while the other half failed to do so.

Table 7.5. Knowledge of hygiene principles and practices

	% Correct	% Incorrect
Which of the following is a food safety rule of personal hygiene?		
• Open cuts or wounds should not covered by dressings		
• Clear fingernail polish is all right		
• It is all right to use a toothpick while working		
• You should wear no jewellery while you work	82	18
Smoking by food handlers in food handling area is to be discouraged because		
• Food might absorb smoke flavours		
• Smokers tend to cough over food		
• Smoker touch their mouths with their fingers	50	50

Food safety training

Investigation in the twenty-two companies revealed a total of 587 full-time employees, and 55 part-time workers. Only sixty-six (11%) of the full-time employees had basic food hygiene training. Hygiene training of staff was documented in twenty (91%) of the establishments, while two (9%) had no such documentation.

Sixteen (73%) of the fish operators claimed to have a training policy, while six (27%) had not. Where such a policy existed, it focused on food handling, personal hygiene and HACCP applications, and took the form of on-job training.

Table 7.6. Food safety training

	Frequency	%
How many of the staff have the basic food hygiene certificate?		
• Full-time	66	11
• Part-time		
Is staff training documented?		
• Yes	20	91
• No	2	9
Do you have a training policy?		
• Yes	16	73
• No	6	27
If yes, what is this policy?		

Customer complaints

Only five establishments admitted receiving some form of complaints from their customers. However, a majority of the establishments stated that the complaints were not related to safety, but to dissatisfaction with labelling or packaging etc. Seventeen (77%) of the establishments had a complaints logbook, while the remaining (23%) did not.

Seeking help on food hygiene matters

Only nine (41%) of the operators had approached the inspection authority for advice on food safety matters, while forty-one percent had not.

Inspection

The time interval between the last inspection visit by a regulatory official and the study visit, as indicated by the fish operators, was investigated in all twenty-two fish establishments. The mean interval was once or twice a month. Such visits to forty-five percent of the premises had resulted in oral advice to the food operators, fourteen percent had received approval without notice, twenty-three percent had been given conditional approval, forty-five percent had received written reports, and nine percent had other outcomes.

The issues identified during regulatory inspections were in 64% of cases structural rather than procedural in nature. Structural nuisance, as used in this study, refers to nuisances which relate to the structure and layout of premises, while procedural nuisances include those the relating to actual handling, processing, preparation or service of food.

A total of 22 fish processing establishments were visited for the current study and surveyed for plant sanitation, with special attention to product quality. Fifteen fish companies have now succeeded in meeting international hygiene standards; others require major changes to meet these standards.

A checklist was published by the FAO (FAO, 1994b) to assess fish factories and to use as an inspection tool. This checklist was used by the researcher as a guide in determining the ability of the plants to meet the international requirements/standards. This checklist includes personal hygiene, sanitation of the establishment and auxiliary facilities, equipment, cleaning and disinfection procedures, pest control, procedures, reception and storage of raw materials, preparation, preservation and packaging, storage and transportation of finished products. In regard to HACCP implementation, it enables verification of progress in implementation of the seven principles through documents and their application inside the processing facility and through a physical audit (see Appendix III).

Generally, the major sanitation problems reveals by the surveyed factories in this study were:

- facilities were poorly designed and constructed causing dirt and dust to enter and contaminate the facility;
- some of the equipment used was rusty, or made of materials such as wood that cannot be sanitized;
- lights over the product were not protected, making it possible for broken glass to drop on the product;
- processing or food handling personnel do not maintain a high degree of personal cleanliness: aprons, hats or hairnets were seldom found to be in use. In a number of cases, hand washing and hand sanitizing stations were not present or were inconveniently located;
- ice was not handled or used in a sanitary manner. In all cases but two, workers were walking with dirty boots into the ice store, thoroughly contaminating the ice. (This could be solved by construction of the room designed to store the ice on a floor above the walk-in area or by a chlorine foot dip in front of the entrance to the ice storage area);
- pest control was inadequate. In a number of plants there were no fly screens in the fish receiving or processing areas;
- back flow preventive devices, required in the U.S. to prevent siphoning of contaminated water into the water supply, were not used in all cases;
- many of the personnel did not seem to be knowledgeable about the basic requirements for plant sanitation and quality control. Most plants did not keep a sanitation checklist or log.

7.4. Section three: Establishing HACCP system

Hazard analysis

When respondents were asked to identify how food poisoning bacteria can be passed on by pests, eighteen (82%) were able to answer correctly, while four (18%) failed to do so.

To test the respondents' level of awareness about certain foodborne disease pathogens[1], four organisms (*Salmonella, Clostridium perfringens, Staphylococcus aureus, Carnpylobacter*) and one chemical product of bacterial metabolic processes (histamine) were listed, and respondents were asked to indicate those they were aware of, and those they were not familiar with. Their responses to these items are shown in Table 7.7.

- All of the respondents were aware of the *Salmonella* organism as a foodborne pathogen.
- Sixteen (73%) of respondents were aware of *Clostridium perfringens*, and six (27%) had no idea about it.
- Eighteen (82%) were aware that *Staphylococcus aureus* is an organism which can cause a foodborne pathogen while four (18%) lacked such knowledge.
- Nine (41%) of respondents were aware of *Carnpylobacter*, while thirteen (59%) percent were not able to identify it as a foodborne pathogen.
- All of the respondents were aware of *Histamine* as a chemical which can cause hazards.

[1] Most of these selected microorganisms and histamine are responsible for biochemical reaction and stored below 2°C enhances the increase of the population of these pathogens. This may

Salmonella and histamine, therefore, had the highest rate of awareness which can cause a foodborne pathogen, while *Campylobacter* had the lowest rate of awareness.

A question was asked as to which organism is most likely to be spread by coughing and sneezing. Thirteen (59%) of the respondents were able to identify the correct answer, while nine (41%) could not.

Table 7.7. Awareness about common foodborne pathogens

	% Correct	% Incorrect
Food poisoning bacteria can be passed on from		
• Wild birds		
• Rodents		
• Insects		
• All of the above	82	18
Which of the following do you think is most likely to be spread by coughing and sneezing?		
• *Salmonella*		
• *Clostridium perfringens*		
• *Staphylococcus aureus*	59	41
• *Vibrio cholera*		
Which of the following terms have you heard of?		
Salmonella		
• Heard of	100	
Clostridium perfringens		
• Heard of	73	
• Not heard of	27	
Staphylococcus aureus		
• Heard of	82	
• Not heard of	18	
Campylobacter		
• Heard of	41	
• Not heard of	59	
Histamine		
• Heard of	100	

contaminate fish during storage, handling, and processing and lead to intoxication and spoilage of fish and fish products stored at elevated temperature (see Chapter Two).

All twenty-two fish establishments were asked various questions on factors which might be influencing them to implement HACCP, their source of information, preparation of HACCP plans and the type of training they needed to implement the HACCP system. The responses to these items are shown in Table 7.8.

Initially, the policies of the various companies were examined with respect to their orientation to quality before the application of the HACCP system. Only one of the companies was certified, with ISO 9002, and twenty-one (95%) were not.

All of the 22 companies (100%) had heard of the strategy prior to the study and had received information about the HACCP system:

- eight (37%) of the companies that participated in this study claimed to have learned about HACCP from scientific journals,
- sixteen (73%) from their collaboration with Ministry of Agriculture and Fisheries,
- ten (45%) from external consultants and
- eleven (50%) from export needs.

Most of the companies received information from more than one source. Most of the companies that participated in this study were informed about HACCP from scientific journals, or through their collaboration with Ministry of Agriculture and Fisheries. This clearly indicates the concern of those companies with the continuous quest for new and more effective methods in the area of production. Also, external consultants played a significant role in informing the companies about the HACCP system. Another source of information was export needs, in other words, the formalities which the importer had to comply with.

More than one answers was given by companies when asked about the main reasons that motivated them to implement HACCP:

- sixteen (72%) said it was due to the European Council Directive 91/493/EEC requirements.
- twelve (55%) said it was to improve quality assurance improvement, and
- five (23%) indicated it was in order to use HACCP as a marketing tool for market development.

The last category of companies was industries with a low market share and which were therefore particularly interested in enhancing public awareness and attaining a good market reputation. No companies had received government financial support in order to implement the HACCP system. This indicates that, up to now, the Government has not provided any support to the companies in their effort to meet international standards.

Availability of HACCP plans

Of the twenty-two operators who had received HACCP information, and claimed that they understood the procedures for setting up the system (Table 7.8), and were able to list examples of the steps involved,

- fifteen (68%) had documented HACCP plans which been approved by regulatory authority.
- seven (32%) had a plan but the regulatory authority had not yet approved it.

On the question as to the method of preparation of the HACCP plan for their processing plant:

- eight (36%) of the companies stated that their HACCP plans were prepared solely by private consultants,
- ten (46%) had prepared them in-house with the assistance of a private consultant,
- three (13%) had prepared them in-house with a guidance of the authority, and
- one (5%) had prepared it in-house without external assistance.

Companies were asked if they were adequately staffed to implement the HACCP system at present. Eighteen (82%) of the fish businesses felt that they were adequately staffed to implement HACCP at the time of the study visit, while five (5%) reported a shortfall (i.e., they lacked a food scientist or quality assurance personnel) and three (14%) were not sure.

Companies were also asked about the preferred HACCP training approach to cope with the needs of training their employees:

- ten (45%) chose to participate in the development of the HACCP plan,
- twelve (55%) percent preferred to attend workshops in this area.

Implementation procedures preferred by fish processing operators

Next, companies were asked, how they would implement the HACCP system if it became mandatory for fish companies under the national food safety policy. Currently, HACCP implementation is compulsory only for those that export their products to the

EU. When asked which implementation procedure they would prefer to follow (Table 7.8),

- fourteen (64%) of the fish companies indicated that they would like to receive some practical assistance from the regulatory authority, in identifying hazards and critical control points, monitoring procedures in their operations, and with actual preparation of their HACCP plans;
- eight (36%) would prefer to submit their own HACCP plans for verification by the regulatory authority.

Table 7.8. Factors influencing HACCP implementation

	Frequency	%
Which of the components of International Standards Organization (ISO) System have you introduced in your company?		
• ISO9002	1	5
• None of the above	21	95
Have you received any information on HACCP?		
• Yes	22	100
• No		
Where from?		
• Scientific journals	8	37
• Through collaboration with the Ministry of Agriculture & Fisheries	16	73
• External consultants	10	45
• Export needs	11	50
Do you have a HACCP plan for your business now?		
• Yes	15	68
• Not approved	7	32
If Yes, how was it prepared?		
• Prepared solely by private consultant	8	36
• Prepared in-house with the assistance of private consultant	10	45
• Prepared in-house with guidance of the authority	3	13
• Prepared in-house without external assistance	1	5
Are you adequately staffed to implement HACCP at present?		
• Yes	18	82
• No	1	5
• I don't know	3	14
What is your preferred HACCP training approach?		
• Participation in the development of HACCP plan	10	45
• Workshops	12	55
If HACCP implementation is made mandatory, what implementation procedure would you prefer?		
• Ready to prepare submit own HACCP plan for approval by the regulatory authority	8	36
• Would require assistance in identification of CCPs, development of monitoring and evaluation procedures, and preparing own plan	14	64

The companies were asked about the total cost of HACCP implementation. This cost estimation appeared to be a very difficult process, because for some of the companies the cost of HACCP implementation was not considered separately, but as part of a broader quality assurance programme. Moreover, in some other cases, in order to implement the new system effectively, plant modification, and/or new facilities had to be constructed or older ones needed to be renovated, which thus resulted in an increase in the total cost of HACCP implementation. Consequently, the companies were asked to analyse and divide the total cost of HACCP implementation into various categories. The results are shown in Figure 7.1. It can be seen that the cost of plant modification account for 62% of the total budget. See Appendix VIII for a summary of the results of the economic survey.

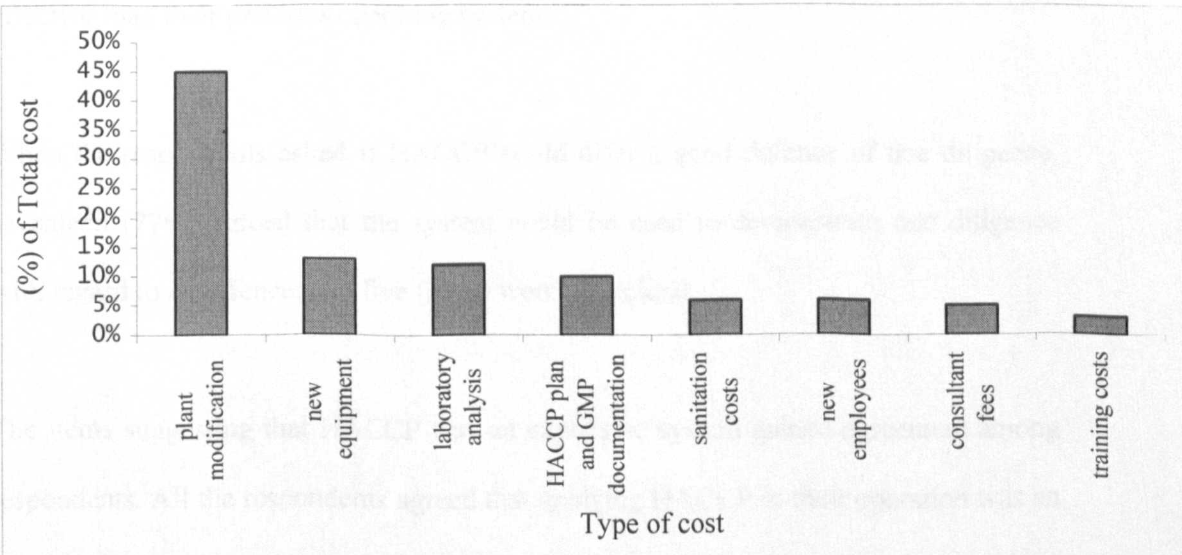

Figure 7.1. Cost categories for HACCP implementation.

Time of HACCP implementation

Next, the companies were asked about the time it took for the HACCP to be well settled in their working procedures. For most of the companies (76%) it took 6 to 12 months, while for the remaining 24% of the companies, it took more than 1 year. This delay was attributed primarily to bad training and organisation and secondly to the lack of infrastructure.

Opinion and attitudes towards HACCP system

Responses to questions which assessed fish business operators' attitudes towards and opinions about HACCP are presented in Table 7.9. On whether HACCP was a more effective system than their previous or other method(s) they had used to secure food safety, fifteen (68%) agreed, and seven (32%) were not sure that HACCP is more effective than their previous operating system.

When the respondents asked if HACCP could offer a good defence of due diligence, seventeen (77%) agreed that the system could be used to demonstrate due diligence with regard to an offence, and five (23%) were undecided.

The items suggesting that HACCP was an expensive system gained agreement among respondents. All the respondents agreed that applying HACCP in their operation was an expensive investment.

Companies were asked whether they thought the HACCP system could be a beneficial to their companies. Fifteen (68%) agreed, while seven (32%) had no opinion.

On whether HACCP was a time consuming strategy, twelve (55%) agreed, two (9%) had no opinion and eight (36%) disagreed.

Table 7.9: Attitudes towards HACCP

	Frequency	%
HACCP is a more effective safety control strategy than your previous/or other method(s) you have used for ensuring food safety.		
• Agree	15	68
• Undecided	7	32
HACCP can be used to support a defence of due diligence		
• Agree	17	77
• Undecided	5	23
HACCP is an expensive strategy		
• Agree	22	100
The HACCP system could gain benefit if applied in my operation(s)		
• Agree	15	68
• Undecided	7	32
HACCP is a time consuming strategy		
• Agree	12	55
• Undecided	2	9
• Disagree	8	36

7.5. Conclusion

The results of survey of the fish processors in Oman regarding the implementation of the HACCP system are presented in this chapter. The objectives were to explore the level of implementation of HACCP systems, to obtain information of industry's hazard awareness and to establish the barriers to HACCP implementation. Results suggested that HACCP implementation is far from complete which in turn may lead to misjudgement on the system. Identified parameters, which may affect HACCP implementation, included the lack of knowledge and expertise and adequate resources. The results presented in this chapter are important when trying to assess the HACCP implementation in developing countries in general and in Oman in particular. The results obtained here are used for further discussion in the following chapters.

Chapter Eight

Discussion

8.1. Introduction

The Omani fishery sector could be severely affected if it produces and exports products that do not meet the quality standards of importing countries, and if it gets tarnished with an international reputation for producing low quality products. It is essential for the Omani government and industry to be aware of these new developments and to apply quality control and inspection procedures that will engender the improved valuation of the Oman's fisheries and continued acceptance of its seafood products in international markets.

In the light of these factors, it was considered important in this study to examine, through case studies, the extent to which HACCP requirements and principles were being applied within the fish industry, to determine how difficult its application has been or was likely to be in practice, to suggest how these new requirement will be received by the fish industry, and how successful it is likely to be. A step-by-step assessment of HACCP programme implementation in Omani fish processing plants was conducted. Fish processors instituting a new HACCP programme are expected to benefit by reviewing and understanding this process, and those who already have a HACCP programme in place should benefit by ensuring that their programmes are focused on safety and comprehensively cover all areas. In addition, the findings provide a useful baseline against which progress in this area can be assessed in the future. In the following sections, the major findings of the study, and their implications for HACCP implementation, are discussed. Whilst the results of the survey are clearly specific to the seafood processing sector, it is also anticipated that they will provide information which is more widely applicable to the Omani food processing sector as a whole.

The study concerns HACCP implementation in Omani fish processing factories. It does not, therefore, address directly all the issues named in Council Directive 91/493/EEC. However, it will become obvious that many of the concerns of the Directive are addressed in a study of HACCP implementation (see Chapter 2 and Appendix X).

8.2. Fish company profile

The number of fish companies dealing with seafood products during 2000 was 39, achieving various capacities and activities. The average capacity of these companies was about 25 tonnes/day. Some of them owned fishing vessels, cold storage or processing plants, while others owned ice plants. These companies were scattered along the coastline of Oman, but the majority are located in the area of the capital, Muscat.

Most of the companies are owned by one person, or by a small group of people. They are managed by their owners who deal with all management issues, usually with little outside help and they are independent businesses, not part of, or owned by, larger companies.

Oman Fisheries Company, established in 1985, was the first fish company. Initially, it had six processing plants along the coast of Oman, which bought fish from fishermen and sold ice to them. In 1988 there were 10 fish processing plants.

Most of these companies rely on independent seller/truckers to supply them with raw material, especially for those located away from the main landing sites[1]. Most truckers purchase fish at the landing sites and transport them to the plants. Some companies, mostly in the Muscat area, buy their fish directly from the central fish markets in Mutrah (4 km from Muscat). Others have their own trucks which they send to the main landing sites. Some contracts exist between companies and fishermen, whereby the company provides them with bait, ice and other facilities on condition that they deliver their catch to them. Other companies have hired some fishermen to fish for them, which has played a substantial role in the increase in demersal fish landings.

The quantity of fish purchased by these companies in 2000 amounted to around 25,000 tonnes (21% of total landings), valued at OR 8 millions. High value species, such as demersal fish (emperor, grouper, seabream and croaker) accounted for 48%; large pelagic fish (yellowfin tuna and kingfish) accounted for to 12%; small pelagics (most of them sardines) for 24% and 3% were sharks. There were 123 tonnes of lobster, 53 tonnes of shrimps and 1743 tonnes of cuttlefish. Most companies deal in and process all types of fish, while two companies process only large pelagics (e.g. yellowfin tuna). In Oman seafood products may be divided into (a) raw seafood, and (b) processed raw foods. Examples of raw seafood are crustaceans and finfish. Processed raw foods include gutted tuna and other species. Generally, most of the operators in the Omani

[1]The main landing sites for large pelagics are located in Sharqiah 400 km from the capital, while those for demersal species are in Al-Wuasta, more than 800 km away, see Fig. 4.1.

fish processing industry, after receiving the raw products, clean, gut, head, fillet and freeze the fish in order to sell it to a wide range of secondary processors, mostly located in the Muscat area. However, some of the companies have branches in the main landing sites such as Sharqiah and Al-Wusta.

Fish processing is almost the same for most of the companies. It is almost entirely in the primary stage, where fish is received and dumped into holding tanks. From here, the fish is conveyed to one or other of the two processing lines (dressing or filleting). The line for dressing whole fish consists of an operator who positions the fish so that the dorsal fin can be removed, and another to place the fish in the deheader. After the head has been removed, the fish are placed in the eviscerator by another operator, after which an operator skins them using a hand-operated skinner. The dressed whole fish are then chilled with water. Next, the fish are sorted into different sizes, and then either placed on hold in a refrigerated room or placed on the belt to be conveyed to the freezer. The fish are then packaged, weighed and stored in frozen storage rooms until being shipped. The fillet line follows a similar sequence of operations: first the fish is placed in a deheader, than the deheaded and slit fish is placed in a filleter/skinner. The skinned fillets are conveyed to a trimming table, where a number of persons cut the whole fillets into nuggets and shank fillets. The fillets are then sorted and held refrigerated until ready to be frozen.

In terms of management, most companies in Oman have a manager and an accountant. The manager is also in charge of marketing. Some plants have quality control personnel, who are responsible for supervision of sorting the incoming material, based on its quality. Fish processing is labour intensive, and most employees are expatriates (Indian and Pakistani), as Omani labour is relatively expensive.

The development of this sector is strongly related to its profitability. So far, the evolution of this sector has been slow. Few new companies have entered the market during the last five years. Although the existing processors are not complaining about the level of profits, it is acknowledged by operators that profits could be improved in the short run by improving the level of hygiene, particularly by using a quality control system (such as HACCP) which most expect to improve the import prices in the international market, to the benefit of the performance of this sector in Oman. The predicted relationship between HACCP implementation and profitability accounts for the evident willingness of most of the companies to invest in new plant (see Appendix VIII).

8.3. Prerequisite programmes

A number of authors and regulations stress that it is essential that GMP be in place before a meaningful HACCP programme can be installed (Chapter III in the Annex to Council Directive 91/493/EEC, NACMCF, 1997; Mortimore and Wallace, 1998; Sprenger, 1995). The advantages of the application of GMP system are that it gives clear, understandable advice; can be designed to meet local regulations, knowledge levels, and practice; can be codified in inspection forms that provide the basis of plant approval criteria; and can focus on the real issues that affect quality (WHO, 1999). Experience within international companies has shown that in certain factories in less developed countries prerequisites are a good place to prioritise activity (cited in

Wallace and Williams, 2001). The implementation of HACCP systems into fish processing factories has proved to be very successful in companies incorporating a GMP system in their processing procedure. Cleaning, hygiene and sanitation procedure, monitoring of received products, temperature monitoring and control, food storage, cross contamination and temperature control, plant layout and equipment, and food hygiene training, are considered the main core of prerequisite programme (see Chapter Two and Appendix X).

Each firm should build HACCP plan upon a strong foundation of prerequisite programmes. Properly designed and implemented prerequisite programmes can reduce the likelihood of occurrence of many potential hazards. This helps limit the number of hazards that need to be controlled under the HACCP plan.

Based on the output of data collected survey conducted in this study (i.e., mainly questionnaire and checklist), firms should make several changes to improve their prerequisite programme controls. These changes provide increase assurance that the hazards are being adequately control. Examples of these changes are

- renovated equipment and facility to reduce the need for pest control chemicals;
- inspection of ingredients and shipping containers for evidence of insanitary conditions;
- updated sanitation procedures to reflect changes in cleaning system and other newly created procedures;
- supplier controls such as approval and certification;
- sanitary design of the facility and equipment;
- receipt of raw materials only from known/approved sources of supply, and

- raw material and ingredient containers marked with date of arrival.

Types of controls use at each firm depend in part, upon the type of incoming ingredients and materials, and upon upstream plant controls.

8.3.1. Cleaning, hygiene and sanitation procedure

A cleaning programme is part of GMP, and is essential to any food-processing environment (Annex to Directive 91/493/EEC, Chapter II, Appendix X). However, cleaning procedures may also be considered as part of the main HACCP plan, and are often critical in preventing serious microbiological contamination (Dillon and Griffith, 1999). Additionally, cleaning itself may cause a chemical or physical hazard if not properly controlled. Therefore, it is important to identify where cross-contamination through poor cleaning can occur. Bryan (1974) reports that two factors contributing to foodborne disease outbreaks were inadequate cleaning of equipment and cross-contamination. Bryan does not, however, identify specific sources of contamination. Stauffer (1971) indicates that in many outbreaks, common links between contaminated fresh foods and cooked food are sinks, knives, cutting boards and hands.

Although there was high recognition among the survey respondents of the need to have a cleaning schedule for their processing operation, the results of this aspect of the study need to be interpreted with some caution, since there were few respondents able to identify correctly the best substance to be used for cleaning and disinfecting inside a refrigerator, freezer or cold store, and to identify the substance which is considered to be a good food contact surface sanitizer (see Table 7.2)..

Prevention of hazards can be achieved by proper management of the cleaning schedules, training staff and carrying out post-cleaning inspections and verifications as recommended by Mortimore and Wallace (1994). Results from the study (questionnaires, interviews and inspections) show, however, that the staff knowledge about proper cleaning is inadequate. The results also point to the need for more post-cleaning equipment inspections. In this case problems can be prevented through the design and management of appropriate cleaning procedures, which could include adequate training of staff and may involve post-cleaning equipment inspections.

Tasks such as cleaning, chemical and pest controls procedures and storage, require motivation from personnel and supervision from managers, in order to ensure satisfactory completion of such tasks. Thus, a manager and HACCP team should develop and apply a cleaning plan and personal hygiene rules that ensure safe preparation of the product. In addition, the manager should provide proper cleaning materials and equipment and allow adequate time for cleaning machinery and processing areas after production has finished.

Because each processing line is likely to be different, different GMP schedules would be expected for each line. A number of details to be included in the GMP codes have been elaborated by regulatory agencies and international organizations although, of necessity, these tend to be somewhat general. The most comprehensive example is the work undertaken by the "Codex Alimentarius Commission" of the United Nations, which has published a series of Recommended Codes of Practices (Codex Alimentarius Commission, 1997b) including general principles of food hygiene (Vol. A), and a number of fish products (Vol. B) including codes for fresh fish, canned fish, frozen fish, shrimp, molluscan shellfish, lobsters, crabs, smoked fish, salted fish and minced fish. In addition, EU Council Directive 91/493/EEC, Chapter III lays down general rules for food premises to maintain cleanness and good repair and conditions.

Cleaning schedules should also be drawn up when specific areas of hazard have been identified in a process or in the building. All areas need attention but some carry a greater risk than others. Each worker should know his cleaning responsibilities within a cleaning plan and the manager should take overall responsibility to ensure that cleaning is done to the correct standard and that a cleaning schedule record is maintained. Wallace and Williams (2001) note that if these issues were dealt with first as part of GMP, the HACCP study will be much more straightforward and the resulting HACCP plan easier to manage.

8.3.2. Monitoring of received products

The Oman fish processing sector is supplied by artisanal fisheries, with a long[2] distribution chain where little control over the raw material is exercised. Raw material losses occur after capture, caused by improper manipulation, storage or conservation in fishing boats. The long period between the capture and the unloading of a ship, in most regions of Oman, causes a decrease in the quality of fresh fish. In addition, the quality control programmes in some plants are still focused on final product control, instead of dynamic process control.

[2] The fish supply chain in Oman is characterised by large numbers of small-scale fisheries, separated by long distances.

The EU Council Directive (91/493/EEC) Annex Chapter V requires the fish processors to conduct checks on raw materials on arrival, to ensure the quality of all process inputs meet this condition, temperature, visual inspection and/or sensory evaluation have to take place (see Appendix X). Compliance with this requirement was reported in Table 7.3. The responses were good, but not perfect, as they should be for full HACCP implementation. Audit would really test compliance, and this was not possible in this study.

In order to make safe products, it is necessary to understand the hazards and risks associated with the relevant raw materials. Either raw material should contain no hazards, or any hazards present must be controllable by processing. The researcher found that most of the surveyed establishments claimed that they checked fish and ingredients for temperature and quality on receipt from truckers or from landing sites. There were, however, no specified and documented procedures for undertaking these checks, and in most cases, monitoring was not related to any predetermined critical limits, thus many establishments were in breach of Decision 94/356/EC (Chapter 2, Annex). The study revealed that criteria for the receipt of fish and ingredients other than the usual visual checks of general appearance, were not specified, documented nor strictly followed on a daily basis. Besides, maximum permissible temperatures were not set, for example, for frozen and chilled fish.

Processors following a well-established HACCP procedure should know how raw materials have been handled at every stage, from when the fish were caught to the time of arrival at plant (i.e., the traceability requirement, now formally laid down in Article 18 of Regulation (EC) No 178/2002 of the European Parliament and the Council laying down the general principles and requirements of food law, with equivalency of imports demanded in Article 11). This will help to establish whether the likely hazards are present at expected or increased levels, and also whether any new, unexpected hazards have emerged. Not only can appropriate assurances not be obtained from the suppliers, but in Oman, such upstream traceablity also does not exist and it is essential to build control measures (such as adopting a risk assessment method) into the operation to cope with the worst-case scenario.

A sensory assessment (appearance, odour) of the raw material immediately before processing maybe sufficient for ascertaining that, until this point, the material has been under control and that spoiled fish or crustacean does not enter the processing area. Time spent in receiving and inspecting fish should be minimised by specifying delivery and scheduling adequate personnel for this function. Growth of bacteria can be controlled by strict temperature control. A temperature below 3°C (Huss, 1992) is a critical control for a full range of likely pathogens, histamine-production, and growth of spoilage bacteria at all stages from catch to distribution of the final product.

Time and temperature recording at specific points and during processing should preferably be controlled automatically. Process flow should be designed to avoid stops and interruptions, and all chill rooms should be supplied with thermometers.

Established GMP as well as sanitation and factory hygiene procedures are crucial for minimizing the contamination of products with bacteria from animal/human reservoir and should be monitored as a daily routine. If these monitoring measures were applied in Oman, they would provide an operational framework on the basis of which unsafe fish and ingredients could be identified and rejected.

8.3.3. Food storage, cross contamination and temperature control

In this section specific questions were asked on matters which have a direct influence on the daily operations, which need to be understood in order to avoid risk. The researcher aimed to assess operators' knowledge by asking questions on appropriate storage, cross contamination and correct operating temperature. Generally, there was a lack of knowledge among respondents about those topics. For instance 7 out 22 operators failed to identify the correct place to store cooked food if only one refrigerator is available. Failing to do so will lead to cross contamination. Fresh products to be frozen or quick-frozen have to be comply with requirements of Chapter IV of the Council Directive 91/493/EEC, storage rooms must have temperature recording device in a place where it can be easily be read. Moreover, only 10 companies gave the correct answer an appropriate operating temperature of a cold store (1 to 5 °C), which consequently again suggests the possibility of high risk in their operation. On the other hand the Council Directive 93/43/EEC (Chapter IX) has emphasized that all food which is handled, stored, packaged, displayed and transported should be protected against any contamination likely to render the food unfit for human consumption, or contaminated in such way that it would be un suited to consumed (see Appendix X). Food must be placed and/or protected to minimize any risk of contamination.

8.3.4. Temperature monitoring and control

Although there was high awareness among the respondents about the need to monitor and document temperature, results on this aspect of the study need to be interpreted with some caution, since there is often a difference between what is known to be desirable, and what is actually done in routine practice. The importance of monitoring cannot be underestimated and it is crucial that the person undertaking the monitoring has a thorough an understanding of the importance of the task and in carrying it out will record the true results. Monitoring is one of the most labour intensive activities (Lee and Singleton, 1998). It therefore makes sense that monitoring needs to be accurate and provides a true indication of the results. Inaccurate and false results are often recorded by employees due to the mistaken belief that they will be punished if the results are not what they should be and that the company wants to see records that indicate control of process. Experience from this study indicates that the presentation of comprehensive records of temperature monitoring does not always mean that temperature is being monitored in practice (i.e., fewer the half of the respondents could identify the correct operating temperature of a refrigerator, see Table 7.4). This may be particularly true in situations where staff assigned with the task of monitoring and recording temperature lack sufficient understanding of the rationale for such an exercise.

The main determinate of fish quality is the time and temperature relationship during handling, and control of these parameters is likely to form the mainstay of many HACCP-based system for quality assurance of fishery products (see Appendix X). At each stage in the process staff have to monitored the times at which products is held at temperature above specified minima (Council Directive 91/493/EEC, Annex Chapter IV, V and VIII and Council Directive 93/43/EEC Annex Chapter IX) storage temperature (chill or frozen) should also be continuously monitored using a recording thermometer.

8.3.5. Plant layout and equipment

Well-designed and constructed plants, with relatively new equipment, help to maintaining hygienic conditions, facilitate cleaning activities, control pest infestations, and enable to tracing of products. Regarding the implementation of HACCP, plant layout and equipment are both important to reduce exposure to hazards. The identification of CPs permits the designation of high risk areas. Also, modern equipment helps in keeping CCPs within critical limits, and when provided with automated monitoring devices, facilitates verification and documentation steps.

This study reveals that most of the fish processors in Oman had problems with their plant construction and layout (see Section 8.6). This quite probably resulted in a high total cost of HACCP implementation. 45% of respondents indicated that plant modification and construction is the most important cost associated with the implementation of HACCP. Most companies require modification or reconstruction to meet sanitation requirements. Modification means improving sanitation conditions within the existing plant, such as wash sinks, hand dips, etc, while reconstruction is required when the general layout does not facilitate orderly handling. Furthermore, 13% of respondents indicated that purchasing new equipment is the second category of cost incurred by the company.

A number of factors should be considered in building a new plant such as physical, geographical (a suitable location) and infrastructure available. A number of authors (Shapton and Shapton, 1991; Hayes, 1985; ICMSF, 1988) and official regulations (e.g. Chapter III in EU Council Directive 91/493/EEC) give detailed information on requirements for buildings, equipment and processing procedures and these do not seem to have consulted been in these cases.

The facility layout has not in general been considered carefully enough in Oman (see Appendix X). Prior to the construction of a new plant or modification of an existing one, the regulatory authority is recommended to analyse the propose plant projects, before construction. The location of any new processing plant, its design, layout, construction and equipment, should ideally be planned in detail with considerable emphasis on the technical, hygienic and sanitary conditions for food processing.

8.3.6. Food safety training

Food business operators have to ensure that food handlers are trained, instructed and supervised in food hygiene matter commensurate with their work activated as required by Chapter X of the Annex to Council Directive 93/43/EEC. The personnel requirement set out in Directive 91/493/EEC is also significant, since it requires high standards of personal health and hygiene.

It is doubtful if any company can implement prerequisites and a HACCP programme without specific training. This is particularly true for a company with limited access to information and often without the time or skills to interpret the HACCP plan.

However, for those businesses, without in-house technical support, it is important not to abandon trainees after familiarisation is completed (Mossell et al., 1999). Further specialist help is required almost certainly.

The present study reveals that only a small number of food handlers have been trained to carry out tasks in way which minimise the likelihood of contamination. Only 11% out of 587 employees working in the fish establishments had food hygiene training. However, larger companies were much more likely than small companies to have employees who had received training.

This study showed that fish establishments had little incentive to train employees (i.e., based on this study, it was observed that a significant proportion of fish operators in Oman rely heavily on unskilled and untrained personnel, who usually come from the lower socio-economic classes with generally low levels of education). This is probably because of the usual high turnover associated with training of staff. Whenever possible, training should be combined with hands on experience as recommended by (Mayes, 1994). All disciplines involved in HACCP implementation, (operatives, supervisors, management, maintenance staff, electricians, sanitation crew etc), should be included in the training given.

Managers should be committed to investing in educating and training employees to build awareness and a positive proactive attitude toward food safety. With such a low number of trained people in fish establishments, all personnel will need a basic understanding of the HACCP concept, how it will apply to their working environment and understanding of the terms "critical limits", "monitoring" procedures and “corrective actions”, and the role of these in control of food safety and why CCP monitoring is vital. It is also important that all personnel understand the relationship between HACCP and the prerequisite programmes. This might include checking raw materials/ingredients, separation of clean and unclean processes as well as production areas, control of every process step and regular monitoring and protocol checking of crucial criteria such as processing and storage temperature, during times, packaging etc.

Holt (1999) noted that the employment of an experienced, technically qualified person is the single most important factor influencing the implementation of HACCP. Management should encourage and recognize the need for training the employees, because even though the HACCP plan may have been created by an expert in food safety, the expert on a particular piece of equipment which helps achieve food safety is likely to be the operator of that piece of equipment (Dillon, 1992). The employees should therefore be involved and participate in the design and development of the HACCP programme to give them a sense of ownership and judgement of the work on hand; as mentioned by Tompkin (1994), plant personnel should be “active participants”.

Training constraints in Oman

The researcher found that the fish processing industry claims to be willing to train employees in food safety area and in HACCP system in particular, although there are some constraints facing trainees and training programmes in Oman. One constraint was that there are few or even no local experts in Oman. Consequently, experts from other countries have to be employed usually at considerable expense. The food processing industries and governmental bodies are often unable to bear the expense of sponsoring a sufficient number of personnel to receive HACCP training. Teaching the application of HACCP systems to the food processing industries in developing countries may requires hard work and a sound knowledge of science, technology and the fine art of training to cope with cultural differences.

Another problem might result from sending under-qualified or inexperienced people on training courses. Unfortunately in Oman there is often a shortage of people with the basic expertise to benefit from the training courses. This practice is essentially a waste of resources, because trainees should have a basic understanding of the technology of the food processing procedure to have a chance of preparing an effective HACCP system for it. Personnel who are not properly trained may themselves be hazardous, in that the HACCP system that they produce or audit may be deficient, but still give the false impression that food safety and quality are being properly monitored.

Another problem in introducing HACCP systems into the Omani seafood industry is that competent and properly trained personnel move to other food industries for a higher salary. Food industries are therefore unable to benefit from the trained personnel in implementing HACCP, or transferring new skills and experience to other staff.

Problems associated with language deserve special mention. Many workers in the industrial sector do not speak or understand English well. Training courses mostly are provided by overseas experts who use English in these courses. This situation could cause major problems for trainees, for instance, translation of basic HACCP concepts such as "hazard" and "risk" into a language that is understood by workers at the plant level, where cultural difference can result in misunderstanding and confusion. Also, different interpretations and definitions of CCPs provided by different institutions do not help trainees in the process of implementation. It is important, therefore, that training and associated literature be in the native language of trainees, and where necessary an interpreter ought to be used to ensure that the trainees adequately understand the concepts of the system.

The final issue concerns training manuals. Many training manuals on HACCP, developed by overseas experts (CFDRA, 1992; FAO, 1995; Stevenson, 1993; Dillon and Griffith, 1996; TFIS, 1994) often confuse people in developing countries because there are several HACCP models available. The FDA's model for HACCP system is based on food safety only. Other models for HACCP programmes, including Codex, and the EU Directive also address the safety issue, while the Canadian QMP programme incorporates quality and wholesomeness issues as well. All essentially have the same intent, but the means to the end are stated differently[3].

More attention should be given to explaining that HACCP systems involve informed judgments of what represent significant hazards and the possible consequences of failure to control those hazards. It is hoped that the problems arising from variation in training manuals and methods will be reduced when influential bodies and experts on HACCP agree to harmonize training manuals. In Oman, governmental collaboration

[3]The EU and Codex HACCP programmes require the company to carry out a hazard analysis on the process. This generally consists of listing the hazards that may be reasonably expected to occur at each step, conducting a hazard analysis and then considering any measures that are to control identified hazards. The QMP system is based on traditional notions of good manufacturing practice (GMP) and regulatory standards, without the requirement to make decisions about the importance or priority of

with the food industries might encourage the adoption of a uniform approach to the introduction of HACCP systems. This step is recommended by researcher through establishing HACCP steering group (Section 5.4.3).

Development of training programme

Government in Oman should provide leadership for the implementation of voluntary safety assurance programmes, through its food control Ministries and Municipalities. It needs to provide extension services to advise the food industry in the development of voluntary safety assurance programmes based on HACCP by establishing a Steering Group (see section 5.4.3), it needs to promote a common understanding of HACCP systems within the food control services, the food industry and consumer groups; and to promote partnerships and cooperation with all interested groups.

In order to carry on training activities on HACCP, Oman should established a training programme. The core activity of this programme should be carrying out through courses, workshops, seminars, and the development of training material relevant to developing Oman needs. The main objective of the programme should be to develop a common understanding of the application of the principals of the HACCP concept to food processing and manufacturing to ensure the production of safe food. This may be achieved by train other trainers. This means to train people in a position to train others and to apply the knowledge gained, and thus contribute to the country self-sufficiency and sustainability in the development and application of HACCP system.

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various issues. Under the QMP system a formal hazard analysis is not required, instead the regulatory agency provides examples of hazards.

In Oman and probably in other developing countries, there is not always sufficient background information to provide a solid scientific base for a realistic and efficient national HACCP application programme, e.g., lack of reliable epidemiological data. Other, more general, problems concern the shifting people attitudes of particularly government fish inspectors from traditional inspection system to HACCP. This hampers the shift to HACCP, and the limited industry feedback required to complete the picture. Therefore, in order to strengthening the HACCP training programme, Oman should established technical cooperative links with other international organizations (WHO, FAO, INFOPESCA, INFOFISH, INFOPECHE and INFOSAMAK) and other technical units and with national training and research institutions and fish inspection services in selected countries, namely European Union, US and Canada. The kind of cooperation maintained with these institutions may include regular exchange of information, provision of training material (manuals, training kits, videotapes, slide shows) and experts acting as lecturers/instructors during training activities. However, the following basic points should be taken into consideration when planning and implementing HACCP training programme.

Trainers are the essential key for the success in training. The training programme should by direct specifically to industry personnel to assist them in understanding the principles and applying them into practices appropriate to their establishment's condition and personnel (Table 8.1). In Oman, one way to conduct such a programme is to let the field inspectors to be the trainers (in the long-run, this will strengthen their roles as educators and enforcers). Fortunately, there are a number of cases where this goal was fully achieved. For instance, Project INT/90/026 carried out two global training courses for trainers of fish inspectors and quality controllers, the first one in St.

John's, NF, Canada, in June 1991, and the second one in Kuala Lumpur, Malaysia, in March, 1992 as reported by Lima dos Santos and Lupin (1996). The advantage of this approach is that these trained inspectors can identify with the processors problems and process conditions and provide technical assistance in the development of the programme as the follow-up of training. It is vital that the trainers have in-depth experience in process technology and a fair amount of field inspection experience, and are actively involved in the inspection of plants so that they can use practical examples that are appropriate to the problem.

Table 8. 1. Suggested training modules designed based on the seven HACCP principles.

Topic	Title	Content
Module I	Prerequlsite Programme • Introductory food hygiene • Plant sanitation • GMP	Prerequisite programmes are the foundation of the HACCP plan. GMP must be adequate and effective. Effective prerequisite programmes will simplify HACCP plan development and will ensure that the integrity of HACCP is maintained. Review existing programmes to verify that all the basic requirements are met and if all necessary controls and documentation are in place.
Module II	HACCP system • HACCP principles and application • Development of HACCP generic model • Quality manual development	Seven principles of HACCP should be covered in detail, enabling regulatory authorities and industry to develop effective, practical, and compatible HACCP systems.
Module III	Critical Limits • International standards and guidelines • Importing countries standards and regulation e.g., EU, Australia, Canada, Japan and U.S.	The trainer review the implementation of HACCP in the fish processing industry in Oman. The module should provide an overview of different countries' regulations concerning HACCP.
Module IV	Monitoring Procedures • Sensory evaluation of fishery products • . Rapid techniques in quality and safety evaluations • Inspection procedures	Participants assign a group case study that is most relevant to their production.
Module V	Verification Procedures • Microbiological evaluation • Chemical evaluation • Laboratory Quality System (based on ISO/IEC Guide 25)	The trainer provide a background on identification assessment, and control of hazards.

8.3.7. Customer complaints

This study reveals that most of the complaints which the fish managers claimed to have received did not relate to safety issues but to matters such as general satisfaction with labelling, packaging or other physical characteristics of products. This is not surprising, since most unsafe practices take place in the fish processing plants and other fish preparation areas rather than at selling and display areas. The level of safety-related complaints might have been more specific if customers had an opportunity to appraise actual processes of fish handling and preparation. On the other hand, it is only when awareness of food hygiene principles among customers is high that they will be in a position to evaluate food preparation and handling procedures in fish processing. Not even a single study has investigated the level of hygiene awareness with regard to food preparation and handling in Oman; thus, it cannot be assured that understanding of hygiene principles exists among the general population. This highlights the need for increased attention to health education in food safety as part of the overall primary health care system. Abdulsalam and Kafoerstein (1994) argue that cost-effectiveness in this area could perhaps be achieved, for instance, by incorporating food safety education into existing materials and campaigns on nutrition education.

8.3.8. Seeking help on food hygiene matters

Only 41% of the respondents indicated that they had ever taken the initiative in contacting the regulatory authority to seek information on hygiene or other issues. This may largely be explained by the perceived emphasis on prescription and enforcement rather than the educational role of regulatory authorities in food safety control. This often leads to the impression of the inspection officer as the enforcer, which weakens the relationship between food regulatory authorities and the food industry. The regulatory authorities have a responsibility to provide leadership in food safety control by accepting and promoting food safety principles for the food processing and manufacturing industry.

It is the role of the regulatory authorities to ensure the appropriate application of HACCP's principal activities by the various food sectors and to facilitate HACCP implementation where necessary. In Oman cooperation between the industry and the regulatory authorities is needed more than ever. As enforcers, regulatory authorities assess the appropriate implementation of HACCP plans and confirm that they are properly designed and effectively implemented. In this stage, new regulations, legislation and instructions may be required to allow regulatory authorities to employ HACCP as an inspection tool (see Chapter Nine). Unfortunately, this has not yet been achieved in Oman, leaving the private sector without defined rules on how to proceed.

8.3.9. Inspection

The approval of establishments for fish export by the Ministry of Agriculture and Fisheries is given according to the sanitary and cleanliness levels[4] in such companies and according to their adherence to all sanitary and health rules related to fisheries products (Appendix X).

[4] Based on the Directive (91/493/EEC) required fish processing establishments and factory vessels to meet specific standards of hygiene. These are defined in the various Chapters of the Annex to the Directive.

The finding on the time interval between last inspection visit by regulatory officials and the study visit has some implications for the implementation of the HACCP system. Since the Ministry of Agriculture and Fisheries is the principal organization providing service to the export industry on fish inspection and quality assurance, the enthusiasm with which they accept HACCP as the basis for a food safety regulatory framework is likely to have a significant impact on the level of acceptance and implementation of the system in the fish processing industry. There is an urgent need for field regulatory officials to consider the inadequacies of traditional approaches to food safety control, and the epidemiological rationale for the application of HACCP (Bryan, 1981b). For an unofficial observer, the HACCP system may appear as yet another addition to the sequence of food safety regulatory mechanisms. Based on analysis of a state-wide implementation of HACCP in the USA Guzewich (1986) indicates that both regulatory officials and food business operators who had been unwilling to get involved with the system became more enthusiastic after having actual experience of it. Comprehensive HACCP training and orientation of food regulatory bodies through workshops, seminars and course centre training is an crucial step towards a wider implementation of the system in any country.

The present study showed that most of the inspection reports issued to the fish businesses by the regulatory authority focus more on structural nuisances than on procedural ones. Traditional inspection procedures have often been criticised for their over-emphasis on aspects of structure and equipment that may not be particularly critical to safety. Unfortunately, risks of procedures and practices which often contribute to outbreaks of foodborne diseases (Bryan, 1988) do not often present themselves at the time of inspection, being more apparent overnight and at other times when inspections may be inconvenient or impracticable. In Oman, food inspection procedures rely on final product inspection and detecting problems after they have been processed into the product. This is an expensive approach especially when serious defects were identified in the final product. The traditional inspection method which has for a long time been and still is followed in Oman has its own limitations, one of which is that operations is carried out with reference to various guidelines, standards and Codes of Practice. In many cases, these documents fail to indicate the relative importance of various requirements. These requirements are stated in very broad terms, such as satisfactory, adequate, suitable, if necessary etc. This leaves interpretation to the inspector, who may place too much emphasis on relatively unimportant factors and thus increase cost without reducing a hazard. Microbiological testing also has some limitations as a control option. These include constraints of time, difficulties relating to sampling and analytical methods. Therefore, use of HACCP as an inspection tool by regulatory agencies can be perceived as a substitute for routine inspection by government officials (see Chapter Five).

The principles of HACCP can easily be incorporated into national fish regulations, but it should be emphasized that HACCP deals with specifics, while regulatory agencies are used to dealing with the general issues, which can be formulated in regulations to cover the whole industry (Dean, 1990). In this case, the HACCP system needs to be tailored to each individual plant and each processing line. This requires close cooperation between regulatory agencies and the food industry. Highly educated people and staff trained in the application of HACCP are needed, as well as mutual respect, understanding, and trust.

To develop a HACCP-based inspection programme, essentially, entails a sequence of steps as follows. First, the facility develops their HACCP plan. The scope of this plan and the system should include not only safety concerns, but plant and food hygiene, and quality standards as well. This makes the plan not only a food safety system, but also a quality management system. After the plan has been developed, the firm sends it to the regulatory authority for review. All HACCP plans should be reviewed at least twice; once for compliance with programme requirements, and finally to make certain nothing was missed by the previous reviews. After each review, a report is generated which lists in detail the reviewer's concerns and comments. The firm can then use these comments to make the necessary changes to ensure future plan approval.

Once the plan is approved, a validation visit is scheduled with the regulatory authority. The validation should be conducted by audit of the facility and its plan and to determine on site whether the plan is accurate and if the firm has followed the written programme. Team auditors should be sent to the facility to assess each and every aspect of the firm's HACCP plan and to determine a facility rating. This rating is used to determine the frequency of future audits. Firms with a history of good ratings should be audited on a less frequent basis than those with lower ratings, as suggested in Section 5.4.3.

8.4. Hazard analysis

The second objective of the present study was to investigate the awareness of different fish hazards that the fish industry may encounter during their processing. The hazard analysis[5] of HACCP system requires the processor to estimate the degree of hazard associated with each commodity produce from the time received to the time leave the plant. While seafood is no more sensitive to processing hazards than are other fresh foods (Chapter Two), the particular methods used by seafood processors require individual attention in designing a safety assurance programme that will match the regulation and industry's needs. The results show that some hazards could not be identified by companies to which they were significant, or they were prioritised after others which posed less risk to company operations (Table 7.7). This might be because the probability of occurrence of a hazard is linked with outbreaks in the past (Bryan, 1996). Such misunderstanding results in incomplete hazard identification. Failure to identify a hazard (principle 1) will immediately lead to failure in applying the right preventive measure according to the level of risk (principles 2 and 3), which will adversely affect the HACCP system's ability to ensure product safety.

Pathogens were regarded as the most important hazards, of a biological nature, for most of the companies. The researcher observed that there was a general lack of knowledge of food poisoning and foodborne infections. For instance, the number of companies that considered *Clostridium perfringens* as hazardous was extremely low (6 out of 22 companies) and only 4 out of 22 companies were able to identify *Staphylococcus aureus* as a foodborne hazard (Table 7.7). The lack of awareness of *Clostridium botulinum* was also noticeable. No previous studies have investigated these aspects among the fish or food processing industry in Oman. Thus, the current study contributes significantly in addressing the apparent lack of information and awareness of pathogens in the fish processing industry.

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[5] Article six and Chapter V of the Council Directive 91/493/EEC requires on shore-based establishments to identity those hazards which associated with their products and to establish a preventive methods to

In the process of identifying hazards, the crucial issue is access to relevant background information on what the real hazards are for a particular product and process. Information from developed countries may not be relevant to the situation in a developing country. Specific hazards in developed countries are normally identified through epidemiological studies, collation of consumer complaints, product alerts etc. In Oman, food processing industries have difficulty obtaining the scientific information necessary for developing sound hazard assessments, or for identifying specific support needed to implement HACCP. Databases on foodborne disease outbreaks, national food poisoning statistics, biological hazards and other reference materials are not readily available, or are non-existent. Such information is often not collated in Oman, as there is no central authority collecting and publishing information on reported outbreaks of foodborne illnesses etc. Also, the collation of such information on foodborne pathogens requires that the person suffering the illness reports to a doctor, who then obtains stool samples for identification of the pathogen; the laboratory carrying out the analysis must report the result to a central authority. This process does not exist in Oman yet, to overcome such constraints, researcher recommended certain steps to be taken by government (see Chapter Five).

8.5. Record keeping and documentation

HACCP Principle 7 (see Section 2.4.3) and Article six of the Council Directive 91/493/EEC requires that effective record-keeping procedures be established to document the HACCP system (see Appendix X). Records may be kept of all areas which are critical to product safety, as written evidence that the HACCP Plan is in

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minimise such hazards (see Appendix X).

compliance (i.e. verification that the system has been working correctly). This will also support a defence under legal action proceedings. The record keeping systems of the companies visited were examined with a view to assessing their adequacy in documenting HACCP activities and monitoring their effectiveness.

The researcher noticed that there was lack of knowledge on what type of information should be included in records and the importance of reviewing and signing records. The records should indicate when control of a CCP is being lost, as that allows the manufacturer to take corrective action to remedy the problem. Records are also useful in providing a basis for the analysis of trends, as well as for internal investigation of any food safety incident that may occur. The records do not all have to be in typed format, but they might be in hand-written documents (e.g. Hazard Analysis Charts and CCP monitoring log sheets). It is also increasingly likely that records in electronic format may be more easily archived, but it is more difficult to prove that they have not been misused, in the event of litigation. With a paper-based system it is extremely useful to allocate a unique reference number to each HACCP Plan. This number may then be used on all pieces of documentation relating to the HACCP Plan and cross-referencing of CCP log sheets, monitor training records, etc.

8.6. Factors influencing HACCP implementation

This study revealed that fish business operators cited a number of factors that might influence them to implement HACCP (external and internal factors). The Omani fish industry is starting to be concerned with purity and quality issues. The main reason for the implementation of the HACCP system in Oman as stated by most of respondents is the European Council Directive[6] No. 91/493/EEU. The implementation of a HACCP system is not, however, a mandatory requirement, except for those processors who export their products to EU. Therefore, in the absence of a legal need voluntary adoption of HACCP will require a full understanding of the system, the procedures to implement it, and the benefits of its application. The issue judged by respondents to have been most important in their decision to implement HACCP was the EU Directive. This suggests that the implementation of HACCP had been largely driven by factors that were external to the firm and that both regulatory and market-based incentives had played a major role.

Other motivations relating to the internal operation and performance of businesses also influenced the decision to implement HACCP. These included improvements in control of the production process and in product quality (internal factors). In most cases, however, the importance attached to these factors was less than for external factors (EU Directive). Unfortunately, the individual impact of these two elements could not be separated out because they simultaneously loaded heavily onto a single factor.

Firms adopt systems like HACCP stemming from both firm-driven, internal incentives and for customer or regulation-driven, external incentives (Holleran and Bredahl, 1997; Lloyds, 1995; Seddon et al., 1993). In a 1993 study of 647 ISO9000 firms across sectors in UK, Seddon et al. (1993) reported that over half (56%) of the respondents were primarily internally motivated in their adoption of the standard, whereas 34% felt

[6]Under the Directive, food business operators are required to identify steps in their processes and activities that are critical to achieving food safety, and to ensure that adequate safety procedures are identified, implemented, maintained and reviewed based on the principles of the HACCP system (see Appendix X).

that adoption was primarily externally motivated (Seddon et al., 1993). A 1995 Lloyds study of 400 UK firms in mechanical engineering, food, services and electronics reported that, within the food sector, 82% of the food sector respondents cited internal motivations (notably the need to improve efficiency and productivity) as the primary motivation for ISO9000 certification (Lloyds, 1995). Overall, over half (52%) of the respondents cited internal factors as the primary adoption motivation, while a smaller percentage (36%) cited external factors as the primary adoption motivation. Note that these results do not mean that the respondents did not give importance to external factors, because many of the respondents cited external factors as secondary drivers for adoption, which is the other way around in the case of Oman, where most of the firms concern more about international markets (external factor) more than improving efficiency and productivity.

Adoption motivation may also be influenced by firm-specific characteristics such as firm size. For example, the results of Seddon et al.'s study suggest that large firms tend to adopt the quality system for internal, firm-driven reasons while the smaller firms adopt the quality system for external, customer-driven reasons. Ultimately, quality system adoption is firm-specific, depending in part upon such factors as firm size, level of existing quality system, scope of quality system and product complexity.

Firms seeking to improve operational efficiency may consider a quality assurance system, although this did not appear to be the case in Oman (by using HACCP as a tool to improve internal operations). By following HACCP procedures, a HACCP-certified firm can improve its operational efficiency by reducing product failure rates, improving management control of the firm's activities, familiarizing staff with production processes, and through establishing corrective action procedures (WHO, 1999). However, many of these benefits are difficult to quantify.

Generally, we can say that the market power of suppliers and customers, the legal environment and degree of involvement in international markets are but a few of the forces affecting a firm's decision to adopt a HACCP system. Another important factor is the degree to which customer requirements and regulations are enforced.

8.7. Availability of HACCP plans

It was found that only fifteen of the twenty-two fish operation establishments had documented and approved HACCP plans, while the remaining seven establishments had documented HACCP plans but these had not yet been approved by regulatory authority. The HACCP plans of selected companies were evaluated and critically examined.

Lack of consistency and clarity in describing the organizational structure/products/processes, CCPs that were needed to assure production of safe foods, and inadequate/inconsistent provision for monitoring, record keeping and verification were some of the notable deficiencies in the Omani HACCP plans. Some firms did mot provide any supporting documentation including the rationale for selecting CCPs or validation studies establishing that the control measure(s) and critical limits(s) were effective. These highlighted that there is not always a clear understanding or agreement on what constitutes a HACCP plan. In some cases, the summary plan was the only document available and the firm had not prepared supporting documentation of the analysis that had been done. In other cases, the HACCP plan was a collection of documents taken from other firms which might be irrelevant to the processing of the firm in question. Without supporting documentation of the hazard analysis and CCP determination, the system would not be able to be as effective as it should be.

One issue considered during this study was the usefulness of standard formats. Standardized approaches often can help ensure that the information needed for a HACCP plan is provided and that the information is presented in an easily and understandable manner.

This may explain why most of fish processors seem to rely heavily on using private consultants in the development of HACCP plans. Most of the available and approved HACCP plans were developed in-house with the assistance of external consultants. It is probable that much of HACCP implementation in the fish industry and perhaps in the wider food industry in Oman would follow this pattern. This may be explained by unfamiliarity with the system and lack of training.

Although, with the absence of local experts, it is necessary that food business operators understand their limitations, and seek appropriate assistance where they lack sufficient understanding of the concept and the required expertise to develop and implement it, it is advisable that HACCP plans should be prepared by fish processors themselves, because some consultants might develop plans which may be difficult to implement (e.g., having too many CCPs) or use what may be called a "ready-made" plan. It is doubtful that those consultants recognise the real hazards associated with the local products, raw material handling and environment aspects.

It is seems that some seafood processors in Oman consider that they have no further obligations when they have developed a HACCP plan, which they can present to their customers as well as to the regulatory authorities. In practice, they may not follow their original HACCP plan because it requires specific procedures and a large amount of paperwork, as well as well-trained personnel to maintained. The regulatory authorities ought to be aware of this attitude and they ought to convince processors to use the HACCP system, even though there is considerable unwillingness to change. It is obviously a waste of time, money and effort to develop HACCP manuals if they are not properly used, and the protection afforded by the HACCP approach to ensuring quality and safety will be lost. The study indicates that the plant management or those assigned with responsibilities for quality are not fully aware of the HACCP system and would at present have difficulty in implementing a HACCP system. They do not regard the system as a way to boost their quality as well as efficiency at work, but they apply it because they have to.

A key factor in the implementation of HACCP is ownership of the process by the industry. Therefore, it is necessary to provide information to the industry about developments in HACCP in order to encourage a full participation by the various processors in the industry. In Oman there is a need for collaboration between the fish industry and regulatory authorities so that HACCP information, knowledge and skills available in one fish business can be harnessed and effectively used to promote better understanding and implementation of the system in others. Because many small sized fish businesses may have some constraints with HACCP implementation, especially in terms of information and expertise, it has been suggested (WHO, 1990) that larger businesses could help by finding appropriate channels through which assistance for the application of the system can be made available to them. This could be done by organising a national seminar/workshops on the HACCP system involving all stakeholders.

Based on the study, the most problems and difficulties associated with well-designed and applying the HACCP system in the Omani fish industry sector at the time of the survey of companies can be summarised as follows (see Appendix X):

(a) *A lack of ability to identified hazards:* Given the time involved in hazard analysis it is important for companies to focus HACCP studies on the group(s) of hazards which pose the greatest threat to public health. For example, for chill-stored products, processors should focus their efforts on *C. botulinum* spores and *Listeria monocytogenes*. In non-heated ready-to-eat (RTE) foods (e.g., cold smoked fish) they should focus their efforts on *L. monocytogeneslg*, in heat treated products before packaging on *Salmonella, Shigella, E.coli* 0157, while the elimination of parasites in RTE-products is a safety concern during processing in low salt RTE-products. Many companies are unable to make these decisions and attempt to study all groups of hazards at once; a process which might end in confusion, overload and a dilution of control.

(b) *Management lack of commitment*: Most companies require owner/managers' initiative to introduce new systems of managing food safety (such as adoption of HACCP). In Oman it seems that companies have little motivation for such change due to their belief that they produce safe food already. Also, HACCP implementation and maintenance is not easy. It requires management commitment, an understanding of the system and its principles, and a commitment of resources to design and monitor the system. To achieve these goals, commitment of managers should be a driving force towards the achievement of all basic prerequisite programmes as well as to develop the HACCP plan and assemble the HACCP team. If this commitment is not available, then inadequate resources will be made available to provide the basic framework essential to achieve the necessary standards (Sprenger, 1995). The uncertain authority of employees who are responsible for taking corrective action is one of the problems that should be considered in Oman. In principle, the top management must support fully the authority of those to whom they give responsibility for taking corrective action. However, sometimes, top management can be influenced more by short-term commercial gain than, for instance, the safety of the plant's products. It is difficult to convince top management fully to accept the HACCP principles, particularly when they concern serious situations, which may materially affect the plant's profitability.

(c) *HACCP plan ownership*: Successful implementation of HACCP systems depends on the involvement of company staff, in particular plant staff, in the design and implementation of the programme. Only through this kind of involvement it is possible to obtain and implement an effective HACCP system, a fact that also guarantees a positive feeling of "ownership". Unfortunately, the results of this study reveal that some companies are relying almost exclusively on the advice of consultants for the design of their plans " ready made Plan". It is true for those companies, without internal technical expertise, who are vulnerable, are welling to take food safety advised from anyone and everyone even when they feel it to be unwarranted.

(d) *Staff motivation and supervision*: Motivation of the HACCP team will contribute to implement and maintain the HACCP system, especially regarding those principles where continuous monitoring and documentation are required. As mentioned by Tompkin (1994), plant personnel must be "active participants" which gives them a sense of ownership and judgement of the work on hand.

(e) *Insufficient technical resources:* Insufficient technical resources have been cited by many respondents as one of the main barriers which prevents HACCP implementation. Companies do not have the full range of skilled technical resources (microbiologist, food chemist, technologist) available to perform the HACCP study. As a result therefore, some of the technical detail required to perform the study may be unavailable. To overcome this constraint (human and material capital) a thorough understanding is needed of HACCP and related subjects, e.g. GMP. Guides for the food industry have been published, by among others, the Institute of Food Science and Technology in the UK (Institute of Food Science and Technology, 1991, 1992). An understanding of the principles of HACCP itself can be gained through HACCP user guides and specific training sessions. Whether or not staffs carry out the HACCP study alone or with outside help, all of the information relevant to the study (e.g. raw materials list, flow diagram, product formulation, times/temperatures of processing) should be prepared before the study starts. A complete list is given by the ICMSF (1988).

(f) *Lack of HACCP team*: It has been noticed that within Omani fish processing plants one person have more than one area of responsibility. The disadvantage is that many responsibilities are concentrated in the hands of one or two people. This results in some difficulties in assembling the HACCP team, conflicts of interest, and in carrying out the HACCP study due to a lack of extensiveness of knowledge. A full HACCP study requires a multi-disciplinary team made up of a number of individuals with specific skills. The team should be provided with all relevant information obtained from other sources; such sources may include published data, codes of practice, industry guidelines, GMP guidelines or consultancy services. The team should also be capable of using such information to ensure the correct identification and control of hazards. It is important that all of the information gained from the above sources be critically evaluated and applied to each company's specific situation; a function in itself which requires a good understanding of HACCP, GMP and unit operations.

(g) *Lack of trained personnel*: Research has shown that the employment of an experienced, technically qualified person is the single most important factor influencing the implementation of HACCP (Holt, 1999). With low numbers of trained staff in Omani fish processors, highly educated people and staff trained in the application of HACCP are needed, as well as mutual respect. All tasks involved in HACCP, whether related to the principles or the prerequisite programme, depend largely on the experience and training of the labour force. HACCP team members in many plants have inadequate resources of skilled manpower. This will greatly affect the application of the HACCP concept and will require great effort to solve it. Therefore, the use of HACCP in Oman might facilitate the formulation of food safety education. Education on the concept of high-risk foods is one area in food hygiene training to provide appropriate technical data on potential hazards and risk characteristics of foods and ingredients. Building food hygiene training on the HACCP approach would have the advantage of ensuring that data on potential hazards, and the attendant preventive and control measures at critical control points are translated into effective training messages (see Ehiri and Morris, 1994; Griffith and Worsfold, 1994; WHO, 1990).

(h) *Financial resources*: Time constraints and resource requirements of HACCP implementation have been cited as crucial factors influencing acceptance and implementation of the system by fish operators in Oman. Generally, there is limited information on financial constraints on HACCP implementation. The commercial cost faced by most processors, to apply the HACCP concept successfully, may be initially quite significant. Kirby (1994) argues that the smaller financial power of small and medium-sized enterprises has three implications with regard to HACCP which make the full implementation of the system especially difficult for them: (a) the cost of the implementation of the system relative to a company's turnover, this relative unit cost being potentially higher in smaller companies compared with larger ones; (b) purchasing power; the smaller purchasing power of smaller companies means that they often cannot exert sufficient influence on their suppliers to move to using HACCP systems; (c) the power that they can exert over clients is limited, making it difficult for them to ensure that the control of hazards is maintained right up to the point of sale. The fact is, in order to apply HACCP in many companies in Oman first need to upgrade their installations and equipment. Accordingly, investment is required in physical structures, such as buildings and equipment, and in human resources management and technological skills (see Section 8.6). The problem of the cost of the implementation of the system relative to the company's turnover is a problem that faces Omani fish operators with the purchase of any new resource and is not specific to HACCP. However, firms lacking a quality assurance system may experience higher costs from adopting HACCP, but may realize greater benefits. Some authors have claimed that initial costs may be recovered by improved productivity, quality and fewer customer complaints (Baird-Parker, 1990). Indeed, most of the benefits of HACCP are of a long-term nature such as reduced wastage through improve process control, more efficient use of resources which will provide a financial reward for the company (Lee and Singleton, 1998).

(i) *Documentation:* One of the criticisms made by surveyed fish processors who are trying to operate the HACCP system concerns its requirement for documentation. For many fish businesses, paperwork of any kind is a burden, and verbal communication plays a major role in their management of their businesses. Therefore, the message which must be delivered is that HACCP aims to ensure food safety with the minimum cost by focusing control at CCP's, as argued by (Moy et al., 1994; Taylor, 2001).

(j) *Lack or shortage of effective and experienced internal auditing staff:* Another constraint in Oman is the shortage of effective and experienced auditing teams. Once a HACCP plan has been developed and introduced into a food operation, it should be maintained on a continuous basis and auditing is a commonly used tool to ensure this (Sperber, 1997). In addition to such routine auditing, the HACCP plan also requires periodic review to demonstrate that it is meeting its objective producing safe food. Auditing involves more than access to records of CCPs, assessment of HACCP manuals, sampling at CCPs and verification of records (Dillon and Griffith, 1996). Auditors should inspect production lines and other facilities to ensure that the manual continues to be relevant, and that any new hazards have been identified and taken into account. It is important to acknowledge that the frequency of auditing and the efficiency of sampling limit the effectiveness of HACCP systems. Audits may occur only at intervals of weeks or months, by which time the products may have been sold or exported. The auditing system gives historic, not contemporaneous information, so there may be long delays before dangers that are not detected by the plant HACCP team are identified by an expert auditor.

8.8. Implementation procedures preferred by fish processing operators

This study showed that sixty-four percent of the fish operators indicated that they would like to see the regulatory authority offer them practical help with the identification of hazards, CCPs and monitoring procedures in their processes (see Table 7.8). Even where the necessary expertise exists, it is unlikely that any authority in Oman, and indeed elsewhere, would be in a position to provide this sort of assistance, given the staffing and resource implications. A role for regulatory authorities in HACCP implementation is to verify that HACCP plans developed by food businesses are effective and correctly followed. This could be achieved through establishment of appropriate verification inspection schedules based on risk, visual inspection of operations to ensure that CCPs are under control, review of records of CCPs, monitoring of critical limits and deviations, random sample collection and analyses.

8.9. Cost of HACCP implementation

The worldwide trend on application of HACCP-based systems in the fish process industry has raised the question of the cost to implement HACCP in existing plants. Consecutively, the industry expects that this investment to be recovered and produce a profit. There have been few studies of the costs and benefits to food businesses of implementing HACCP. As a consequence, it is difficult to evaluate the extent to which the costs and benefits to businesses act as a motivation to the further adoption of HACCP within the food sector in Oman.

The cost analysis of HACCP implementation is an important element. The reasons are that a reliable cost analysis can be useful in analysing actual industry response to HACCP. Data are crucial when HACCP becomes a mandatory approach. In addition, a detailed cost analysis can give important insights into the accuracy of the forecasting methods used by the regulatory impact analysis (Colatore and Caswell, 1998). In addition, it is assumed that the cost analysis will allow the plant manager to analyse the costs and returns from operating the plant at various levels of scale in order to maximize net returns (Cato, 1998). Seafood quality and safety, and thus HACCP, affects the costs and returns of each plant.

The third objective of this study is to quantify the cost associated with HACCP implementation. Fish companies were asked about the total cost of HACCP implementation. This cost estimation appeared to be a very difficult process, because for some of the companies, the cost of HACCP implementation was not considered separately but as part of the cost of a broader quality assurance programme. Moreover, in some other cases, in order to effectively implement the new system, plant modification, and/or new facilities had to be constructed or older ones needed to be renovated, which thus resulted in an increase in the total cost of HACCP implementation. Consequently, the companies were asked to analyse and divide the total cost of HACCP implementation into various categories. The components of HACCP costs in Omani seafood industry are as follows:

(a) 45% of respondents indicated that plant modification and construction is the most important cost associated with the implementation of HACCP. Most companies require modification or reconstruction to meet sanitation requirements. Modification means improving sanitation conditions within the existing plant, such as wash sinks, hand dips, etc, while reconstruction is required when the general layout does not facilitate orderly product handling. Modification and reconstruction costs depend on the size and type of product produced by the company.

(b) 13% of respondents indicated that purchasing new equipment is the second category of cost incurred by the company.

(c) 12% of respondents mention laboratory analysis. There are additional costs associated with external laboratory analysis as well as installation of internal laboratories. Under the new regulations (EU Council Directives 91/493/EEC and 93/43/EEC) companies are required to carry out chemical and microbiological analysis. Currently, these tests are done only upon customers' requests. Only one company in Oman has a laboratory, which is not functioning yet.

(d) 10% of respondents cited developing HACCP plan and GMP documentation. A typical HACCP documentation requires detailed description of the processes (by product) with identification of hazards and critical control points. Much of the document focuses on sanitation and hygiene measures. The development of such documents is usually done by outside experts.

(e) 6% of the sample drew attention to sanitation costs.

(f) 6% saw hiring new employees as a major cost. The cost of hiring new employees includes the cost of a qualified quality manager to monitor the system and provide leadership to workers. Many companies are in need of qualified workers for monitoring, record keeping and statistical control as required by HACCP. Some companies have a qualified quality control manager. Most quality control managers have been hired recently to meet the quality requirements of EU customers.

(g) 5% of respondents mentioned consultant fees. A consultant is needed to check the layout of the company, assess quality practices and suggest modifications to the actual settings. Many companies indicated they consulted experts in the field to assess their quality requirements. This shows strong interest in the standards mainly among companies exporting to the EU markets. Consultant fees depend on the tasks and frequency of visits.

(h) 3% cited training costs. Training sessions need to be provided for management and floor workers, on the concept of HACCP and GMP. Some employees receive only in house training, while others are sent to special training programmes on HACCP. A few companies indicated that at least one person, usually the quality manager, has received some kind of HACCP training. Training cost depends also on the number of programmes which have to attended.

HACCP costs are difficult to quantify because costs differ across plants and firms depending on plant size, scope of HACCP (safety or quality), and production process complexity. Furthermore, an implication of cost analysis of HACCP is that firms do not tend to track many of the HACCP costs, such as start-up costs, and annual maintenance costs is the case in Omani fish plants. Once a start-up cost is identified, it may be difficult to quantify. For example, some firms stated that they had not tracked all the steps and person hours involved in drafting the HACCP manual. Throughout the process, a firm incurs costs in documenting its production process, establishing and conducting internal audits, and establishing corrective action systems, to comply with the system.

Considering the results as a whole, however, plant modification and construction was the cost that was most frequently incurred and which was most frequently ranked as the greatest cost. The survey results suggest that there is significant variation in the costs of implementing HACCP between individual plants. It is evident, however, that the most widespread costs are associated with tangible elements such as investment in changes to plant structure, new equipment, etc., rather than relatively intangible elements such as staff training and hazard knowledge.

Consequently, the companies spent a lot of money in getting the assistance of consultants in modifying their plants to satisfy EU requirements[7]. However, this study showed that there appears to be a lack of clear understanding of the basic requirements of the EU Council Directives No. 91/493/EEC and 93/43/EEC with respect to plant construction and layout, and infrastructure requirements. As a result, many factories have spent their resources on cosmetic changes, neglecting vital areas which need

[7]The EU ban on seafood exports from Oman was partially lifted in 1998. Fifteen seafood export-processing companies were allowed to export to EU countries, while others are still waiting.

urgent attention, such as improving hazard knowledge, educating floor workers and continuing investing in training.

In the case of Oman, this suggests that the circumstances of individual firms and the standards to which they operated prior to the implementation of HACCP have a large influence on the associated costs (i.e., lack of existing standards and codes). Firms that previously had not operated to standards of GMPs and/or had low numbers of trained work force, as they might require expertise to be able to implement HACCP in an efficient and effective manner. Other firms, however, might need to buy this expertise, for example from a consultant.

In a study of the cost of implementing HACCP in 192 plants in the UK dairy processing sector (Henson et al., 1999), 45.5% of respondents attributed the cost to the staff time in documenting the system to be the most important cost associated with the implementation of HACCP, 16.7% of respondents judged external consultants, 14.1% cited staff training, 7.7% investment in new equipment, 6.5% structural change in plant, and 6.1% managerial change. In addition, in a survey of the cost of upgrading the Bangladeshi frozen shrimp processing sector to adequate technical and sanitary standards and maintaining a HACCP programme, the total expenditures were as follows: plant repair and modifications represented 70%, laboratory installation was 13% and added equipment cleaning 10% (Cato and Lima dos Santos, 1998). The foregoing HACCP implementation experiences in both developed and developing countries indicate that HACCP implementation in developing countries (such as Oman and Bangladesh) imposes a greater cost burden on the industry compared to developed countries, where most of the cost is for plant reconstruction and modification. This suggests the need for a coherent food standard that takes into account plant construction and layout, yet in Oman there is no such standard to cover this area. Therefore, prior to the construction of a new plant or modification of an existing one, the regulatory authority has to analyse the proposed plant projects, before construction. The location of a processing establishment, its design, layout, construction and equipment, should be planned in detail with considerable emphasis on the technical, hygienic and sanitary conditions for food processing. A proper flow diagram of the operation should be prepared. Only a well organized workflow will assure the maximum efficiency of the operation, avoid cross contamination and undesirable delays on the processing line and produce a better quality product. Moreover, due to lack of a quality assurance system prior to implementation of HACCP, firms experience higher costs from adopting HACCP, but may realize greater benefits (international market access). In other words, the cost of implementing HACCP also depends on how far the existing facilities and procedures are from a basic HACCP condition. The further they are, the more costly it will be. Conversely, firms with long-established quality control systems may cite few benefits from the HACCP system.

8.10. Time of HACCP implementation

Companies were asked about the time it took the HACCP to be well settled in their working procedures. For most of the companies (76%) it took 6 to 12 months, while the remaining 24% of the companies took more than 1 year. This delay was attributed primarily to low training and organisation and secondly to the lack of infrastructure. Other factors might also influence the time frame, for example, the complexity of the product, nature and severity of the potential risks, the amount of resources available, and management commitment. Stevenson and Bernard (1993) reported that for most operations, it should be anticipated that it will take at least three to six months of planning, organizing and training to reach the stage at which the implementation process can begin. In the survey referred to above on the UK dairy (Henson et al., 1999), respondents were asked to estimate how long it had taken to implement their HACCP system from the time they had first started to plan the system until it was fully operational. Around 80% of respondents estimated that it had taken 12 months or less to implement HACCP in their plant. However, a small but not insignificant minority (around 12%), estimated that it had taken more than 18 months. One way to approach this is to begin with one product on one production line and utilize this as a HACCP training ground. After the plan is developed and implementation begins, the HACCP team should meet at least monthly to review all aspects, records, successes and failures of the procedure. There should be a monthly review of the plan to assure that all necessary critical control points have been identified and to determine whether all those originally identified are, indeed.

8.11. Opinions and attitudes towards HACCP system

Responses to questions which assessed fish business operators' attitudes towards and opinions about HACCP are presented in Table 7.9. when asked whether HACCP was a more effective system than their previous or other method(s) they had used to secure food safety, fifteen (68%) agreed, and seven (32%) were not sure that HACCP is more effective than their previous operating system.

Although three years have passed since the introduction of HACCP in the seafood industry as a prerequisite for export to the European Union, some companies do not feel a big difference after implementing HACCP. It would be wrong to assume that the companies are the only ones to blame. Some of problems are related to the way that EU Council Directives No. 91/493/EEC and 93/43/EEC was imposed on the fish exporters in Oman. This Directive was introduced by the regulatory authority without considering whether the industry and regulatory authority themselves were prepared to implement it, introducing confusion and hesitation in the system. Further, it did not give sufficient time for businesses to adjust their operations to the change and to locate the necessary resources to adopt HACCP. A similar situation occurred in the USA between central and local heath agencies (Bryan, 1988). Governments across the EU reacted, by giving a two-year period for adjustment, in which enforcement authorities should assist in helping rather than prosecuting businesses (Panisello et al., 1999). Now, three years later, is difficult to assess companies' opinions on HACCP, and probably even harder to convince them fully of its advantages. The main tasks facing the authority now are to convince the industry that HACCP is a cost-effective system which enables companies to produce safe foods and reduce rejection, and to educate the industry about HACCP principles.

When the respondents asked if HACCP could offer a good defence of due diligence, the majority of the respondents felt that the system could be used to demonstrate due diligence with regard to an offence. It is now widely accepted that HACCP presents the food industry with the most effective management tool to secure safe food. As such, the adoption of its principles will offer a legal defence (in many countries) in the event of an outbreak of foodborne disease. The application of the "due diligence[8]" defence against food safety offences was introduced originally into U.K. food legislation in 1990. Legally, due diligence is a relative term which means, "doing everything reasonable, but not everything possible" (Words and phrases, 1965, p. 141). Under this defence, suppliers of food must demonstrate that they have done all that is reasonably possible to ensure that the food they handle and any food obtained from upstream suppliers conforms to statutory food safety standards (Caswell and Henson, 1997; Henson and Northen, 1997; Hobbs and Kerr, 1992). In most cases, this requires that food suppliers adopt HACCP.

All the respondents agreed that applying HACCP in their operation was an expensive investment. It is true that adopting the HACCP system will burden companies, especially small companies, since they have less access to information, fewer resources to hire experts or replace equipment, and fewer trained employees. Generally, we can say that costs and benefits are usually positively correlated. For those companies that already have basic quality management programmes, the cost associated with a HACCP programme might be minimal. Those companies without quality management programmes will incur some cost; however the exact amount depends upon the size and type of operation and the number of personnel to be trained.

Moreover, many of the benefits of HACCP are of a long-term nature, such as reduced wastage through improved process control, more efficient use of resources which will provide a financial reward for the company (Lee and Singleton, 1998). HACCP is a useful tools with which to focus attention on the aspects of food production that impact

[8]"...a defence for the person charged to prove that he took all reasonable precautions and exercised all due diligence to avoid the commission of the offence by himself or by a person under his control."

on food safety; and it is by filtering out the less essential controls that management can give its full attention to the critical control points of the production process. Managing by exception, through focusing on what is important, allows small companies to maximise the benefits from their efforts.

Companies were asked whether they thought the HACCP system could be a beneficial to their companies. Fifteen (68%) agreed, while seven (32%) had no opinion. Firms were asked to provide with any available information on the benefits the firms attributed to their HACCP programme. Most of the information provided was in a narrative form. Researcher found that trying to quantify this type of information is difficult because, as one firm advised, "employees work more efficiently and have greater awareness of food safety". Improvement in employee performance is perhaps one of most significant benefit from HACCP expressed to the researcher by the firms.

Regardless of the cost involved, there will be benefits both industry-wide and company specific. The industry as a whole will project a stronger quality image to the international market. At the company level, HACCP is a preventive programme that helps spot problems before they occur, improving production efficiency and decreasing wastage and it will keep consumer complaints down.

HACCP is a clear benefit to those companies seeking to expand their markets. This is very evident for those who attempt to exports to international markets (becoming a prerequisite for export trading) whose contracts often require documented evidence of a HACCP system from their suppliers.

(Holleran et al., 1999).

On the question of whether implementation of HACCP was considered a time consuming, most respondents ranked the HACCP strategy as time consuming. This might be due to insufficient training, lack of knowledge and technical expertise, and less access to information.

Chapter Nine

Conclusion and Recommendations

9.1. Conclusion

National and international awareness of the importance of food safety is increasing as a result of the identification of emerging foodborne pathogens and new hazards from imported and domestically produced foods. The food that we consume reaches the consumer through long chains of industrial production and distribution. Opportunities exist for contamination during production, harvesting, processing, packaging, transportation, preparation, storage, and service. Processing or preparation conditions may lead to survival of pathogens or toxins, and time-temperature abuse can allow proliferation of pathogenic bacteria and moulds. Safer food has many benefits: less human suffering from foodborne diseases, lower cost of public health, fewer barriers to world trade, lower loss of labour productivity and better overall food security (see Chapter Two). Food safety could indeed be considered one of the most important concerns of our time.

Oman has many competing priorities in its health agendas, and food safety has not, in the past, been recognised as a vital public health issue. Worldwide, however, it is becoming clear that foodborne disease has a significant impact on health. The globalisation of the food trade and the development of international food standards have raised awareness of food safety in Oman. Placing it on the political agenda is the first vital step in reducing foodborne illness, improving food quality, and consequently stimulating international trade.

The future of food safety in Oman, and probably elsewhere, depends, to a large extent, on how the problems hindering it can be identified and solved so that the objectives of sound quality assurance can be realized. The need for effective food control suitable for Oman cannot be over-emphasized. The proper functioning of food control requires a multidisciplinary effort and participation of several departments and organisations within a country (FAO/WHO/UNESCO/UNICEF, 1972). It is therefore important to review the existing systems to identify gaps or overlap, and then to clearly define the food safety responsibilities of the authorities involved.

The responsibility for food safety in Oman involves multiple agencies and each departments or institution has its legislation and inspection procedures (Chapter Five). Thus, the food safety systems and institutions in Oman suffer from a number of weaknesses which make them vulnerable in addressing food safety and quality issues. The weaknesses include the absence of a number of basic elements of an effective national food control system including: basic infrastructure; national food safety and quality strategies and policies: food legislation; food inspection services; food control laboratories; effective participation in the work of international standard setting; implementing quality and safety assurance systems throughout the food chain; collaboration and cooperation of national and sub-national agencies; and scientific and technical expertise (described in Chapters Four and Five). Therefore, the development of clear policies and documents identifying the roles and responsibilities of all parties in a food emergency situation is an important step towards strengthening national food safety programmes.

Fisheries have traditionally played a significant role in the social and economic development of the Sultanate of Oman (see Chapter Four). They have been an important source of nutritious food and the primary means of livelihood for thousands of fishermen and their dependents in many communities along Oman's 1700 kilometres coastline (Chapter Four). Changes in world trading agreements have affected the competitiveness of Omani fresh and frozen fish exports. Maintaining fish exports in the light of changing food regulations (e.g. EU Council Directive No. 91/493/EEC) makes a significant contribution to the economy. The long-term solution for Omani fish sector is to sustain or expand the demand for their products in world markets lies in building up the trust and confidence of importing countries in the quality and safety of the exported foods.

If Oman is to secure and maintain markets abroad, and protect and preserve the quality image of its exported food products, Oman should modernise food safety policy based on quality assurance programmes as required by the major fish importing countries (as outlined in Chapter Three). The food export trade needs to be reorganised and harmonized applying standards of the EU regulations, FAO/WHO Codex Alimentarius Commission and WTO recommendations in order to ensure that the country's exports are accepted without question in world markets.

In order to protect their consumers from food poisoning and intoxication, the international market, including the EU, adopted several measures to ensure that imports from exporting countries. Such measures include legislation, inspections procedures and testing for pathogenic microorganisms and toxins in fish products entering the EU (discussed in Chapter Three and Appendix X of the thesis and Council Directive 91/493/EEC).

EU legislation implies that imports of Omani fishery products into the EU will be possible if exporting plants meet requirements at least equivalent to those enforced in the EU, in terms of plant design, construction and layout; and if fishery products of exporting plants are produced under the same sanitary and control conditions as those established in Member States. These conditions, as set out in Directive 91/493/EEC and subsequent legislation, relate not only to personnel hygiene and plant sanitation but also to quality assurance at the industry level. The fish industry will be responsible for implementing a quality assurance programme that has been audited and approved by a certified competent authority which will be responsible for monitoring its implementation.

In an effort to comply with these EU requirements, the Omani Government has undertaken a number of initiatives to address the concerns of the Commission in an attempt to have the restrictions suspended and ultimately to get approval for the export of fish to the EU (see Chapter Three and Appendix X). The Government of Oman, through the Ministry of Agriculture and Fisheries, has since introduced measures to ensure that the fisheries sector conforms to required standards. These efforts included a formulation of national standards in line with international norms, and requirements for the fish processing sector to institute measures to bring the sector to a satisfactory level of standards compliance. The Quality Control Act for seafood export issued in 1997 (referred to in Chapter 3 as QCA-97), stipulates the requirements for fish handling and quality assurance at various stages of the fish production chain. Fish processors have since undertaken major renovation works to modernize their fish processing facilities (see Appendix VIII) to the required standards and specifications for national and EU requirements (Council Directive 91/493/EEC).

Yet despite of these improvements, much remains to be done to ensure that satisfactory hygiene and quality fish production is maintained at all fish chain supply. This study has identified a number of areas where improvement is still required (see Chapters Three, Four and Eight). One of these is to ensuring that the handling of fish by vendors before purchase for processing is done in accordance with acceptable practice. This should include ensuring that equipment necessary to maintain high levels of hygiene are provided at landing sites. Landing jetties should have clean potable water. Processing plant layout and structural design in some establishments can be improved to avoid product cross contamination.

The EU regulations for the import of fish and fishery products requires a shift from the traditional end-product inspection and certification to the implementation of a preventive HACCP-based quality assurance approach. The study shows that Omani businesses are very concerned about quality control but are not fully informed about international regulations (see Chapter Eight). After the EU restrictions on Oman exports, this concern has increased. This presents Oman fish exporters with new challenges to update and upgrade processing and packing facilities to meet the minimal requirements of EU in terms of construction and layout, to train workers and enforce hygienic practices among them, to develop and implement quality assurance programmes based on the HACCP concept, to contribute to government efforts to improve handling on board and modernize landing sites, by investing in ice plants and adequate cold chain systems.

In Oman, fish plays an important role as food, a source of income and employment (see Chapter Four). The analyses of the Oman fish supply chain and related fish quality assurance, revealed the dominance of traditional fisheries and traditional methods of preservation. Quality problems in the Omani seafood industry have traditionally been poorly documented. Most of them derive from poor handling of raw materials and physical abuse. Ninety percent of the fish landed in Oman is caught by traditional fishermen (2000), who use fibreglass boats. Fishing may take several hours directly under the sun and temperatures can reach up to 40°C in summer. Exposure of fatty fish to sun, air and ambient temperature for a few hours, is sufficient to introduce severe quality loss and cause early chemical spoilage. In view of the Seafood Directive, which requires hygienic fish handling and immediate cooling of the catch (Chapters II and IV), the fishing method alone could, thus, lead to departure from its requirements in Oman. Unless a premium is paid on high quality fish, fishermen are unlikely to not change the fishing habits to which they have become accustomed, especially when this would imply the greater effort of more frequent collection trips. Assuming that the habits associated with this method of fishing were to be changed for the sake of quality, the size of the boat (3-10 m) would, still present problems if ice and fish boxes are to be carried at the same time. In order for the fisherman to meet the required EU standards therefore, the size of the some boats may have to be increased to create room for ice and fish boxes. This thesis makes no attempt to offer precise prescriptions on the configuration of the traditional fleet required to meet hygiene standards, but improving standards in the direction of modern international thinking demands careful strategic thinking on the part of the State. Among other things the low educational status of many of the industry's participants makes moves towards a more advanced mode of operations doubly difficult.

The EEC Council Directive 91/493/EEC (Chapter II) implies that unloading and transportation equipment at the fish landing sites should be constructed from a material that is easy to clean and disinfect. In addition the unloading and landing operations must maintain the quality of the fish.

At most landing sites, fish is carried on hands or dragged on the ground, depending on fish size. From the landing sites, the same methods are used to transport fish to the waiting pick-up vehicles. Fish is packed onto these vehicles to a depth of 2m on average without any form of insulation or ice. Fish is then transported under ambient temperatures of 25-40 °C for a distance of 12-200 km, depending on the location of the secondary buyers. At market places, fish is sold from vehicles to fishmongers who in turn display/sale the fish from the floor or from an elevated platform (ice is seldom used). To meet international standards the State will have to facilitate an improvement in fish markets. New fish markets should be constructed to meet hygienic standards, to ensure a proper care and treatment of fish, which would bring about an improvement in the fish quality of the fish sold in those markets (see Appendix IV for a statement of recommendations to improve fish markets in Oman).

This study has been aimed to introduce, explain and explore the possible implications of the development and maintenance of HACCP systems in the fish industry. The findings of this study support the hypothesis that the HACCP system is not well adopted in the fish industry in Oman, and that many fish business operators presently lack sufficient information about the system and methods for its application. Equally important is the fact that a few of the fish business operators who are aware of the system are presently unsure of what is required of them in the implementation of the system. This is largely predictable, given that this study was conducted only three years after the regulatory authority required implementation of HACCP to meet the requirements of the importing countries (EU Council Directive 91/493/EEC). The Results also indicate that there is a need to introduce HACCP into companies by facilitating the hazard analysis part of the system, providing a better understanding of risks on which decisions can be based, and also facilitating formulation of control measures and critical limits to guarantee product safety (see Chapter Eight).

Results related to the awareness of different hazards by the food industry were also revealing. Survey results suggested that companies fail to identify some hazards (especially biological hazards) which are significant to them. This will result in incomplete hazard identification seriously compromising the effectiveness of the HACCP system to ensure product safety. This presents a great challenge to the training role of fish regulatory authorities, highlighting the need for the dissemination of information about the system to those who have responsibility for its practical implementation, for the assurance of food safety.

It seems that among the problems that companies face during the implementation of an HACCP system are the lack of quality control laboratories, employees' lack of information on subjects of hygiene and safety, and lack of appropriate control systems (i.e., time, temperature, humidity, pressure, etc.). As yet, none of these problems have been directly and systematically faced by the companies surveyed or by the State.

The above-mentioned problems are quite significant and should be faced prior to the development and implementation of an HACCP system, otherwise HACCP will become ineffective. In order to overcome such problems, financial support from the government of Oman might be considered. However, fish processors industries are trying to implement HACCP alone, without any significant support.

The sector most affected by the EU's restrictions on exports is fish processing. The EU's restrictions have had a significant impact on fish processors, both in terms of the economic performance of individual companies and the manner in which the sector as a whole is organized. Many processors have had to invest significantly to upgrade their processing facilities and to improve their procedures so as to meet the EU's hygiene requirements (see Chapters Seven and Eight and Appendix VIII). The improvements required to obtain approval for export to the EU include upgrading of buildings and/or equipment, improvements to laboratory facilities, implementing HACCP plans, and training of staff. Whilst the investment costs for associated factory improvement is high, the cost of execution appears to be modest. In any event, both costs are recoverable (see Appendix VIII) and the industry has demonstrated a willingness to invest in the expectation of adequate returns as a result of penetrating the most lucrative markets.

The introduction of the HACCP system in the Omani fish and fishery product industry or indeed the food industry as a whole, implies the application of a scientifically-based approach, as the best strategy that offers greater security to the seafood producers and consumer.

Ideally the industry and the regulatory agencies need to cooperate to develop a strategy for the implementation of HACCP. Part of this strategy should include the shift to increased industry ownership and responsibility for food safety. The adoption of HACCP simply to satisfy a regulatory requirement has the potential to lead to failure in that company and ultimately in the entire industry.

The successful implementation of HACCP in the seafood industry depends on the ability of the staff of individual plants to identify potential hazards and critical control points; on support from management, often in response to the requirements of export markets; on training and encouragement from regulatory authority; on the level of technology in the individual plants; and on the incentives from management, for appropriate actions to be taken.

Experience in developing HACCP for food processing has proved that safety assurance in a given process depends on sound prerequisite programmes which support the introduction of HACCP (referred to in Chapter 2). The implementation of a viable HACCP system in the absence of an adequate prerequisite programme does not seem to be a coherent possibility.

Members of the HACCP team should be adequately qualified in order to be able to detect all possible hazards. Since companies do not employ the necessary scientific personnel, they are forced to seek advice from external consultants. The above problems could be avoided if members of the HACCP team could obtain their training in Oman.

From the foregoing discussion, it should be clear that the problems that have been discussed do not result from defects in the HACCP concept or in its performance. They are problems arising from deficiencies in the current level of development of HACCP in Oman. Ensuring adequate levels of commitment and training of the relevant personnel can solve most of them.

In conclusion, the implementation of a quality assurance system, such as HACCP, is an issue fundamental to long-term company survival in comparative global market, putting safety and quality at the top of the list of priorities.

It is suggested that there should be encouragement for companies undertaking the development and implementation of HACCP systems. In Oman, it has been observed that processors have been keen to develop HACCP systems and to improve all aspects of their food safety sýstem despite the somewhat less than supportive conditions such as lack of industry guidelines and codes and differing export compliance issues.

9.2. Recommendations

From the foregoing discussion, as well as the entire research exercise, the following recommendations are suggested. Although much of the thesis concerns the fish processing sector, much of the discussion and analysis are relevant to the food sector as a whole so the researcher has sought to employ the lessons learned in the widest possible context.

- The coordination of existing food safety activities needs to be improved to reduce duplication of activities and unnecessary waste. This can be done by re-evaluation of all existing services and facilities (Chapter Five). It is important to consider available technology, expertise and general level of development, using the guidelines provided by FAO, WHO and Codex. The standards adopted by international organisations such as the Codex standards should be adopted where necessary, instead of Oman wasting energy and large amounts of money trying to develop its own standards.
- As part of the introduction of a food safety strategy programme, the Government should develop a national priority classification system for food business. This would classify businesses into risk categories (high, medium and low), based on the type of food, the activity of the business, the method of processing and the customer base. The three levels would then determine the initial frequency of audit and thus enable the State to use its limited resources more efficiently.
- Establishing food contamination monitoring from fisherman or farm to consumption should be a priority for food safety control, and this will help prevent food losses, reduce foodborne illnesses and support food safety awareness. In addition, certain areas require urgent food safety monitoring in the existing services. These include: the use of fertilisers and pesticides in agriculture, slaughtering activities, environmental sanitation and food handling and presentation in open-air markets and on the streets, processing, storage and transportation of food, control of rodents, insects and zoonotic infections, industrial waste management and disposals, food distribution channels and patterns (noted Chapters Four and Five).

- An Oman Food Standards Code should be established (Chapter Five). This code should include general standards on labelling, advertising, date marking, food additives, flavourings, specifications for identity and the purity of food additives, vitamins, minerals and other added nutrients and residues in food. Other standards would cover specific types of food such as cereals, meat, fish and egg products, sugar and confectionery, gelatine, fats and oils, nut products, vegetables, milk and dairy products, condiments, fruits and soft drinks, alcoholic beverages, tea and coffee.
- Provisions in new law regarding inspection of imported food need to be implemented in order to deal with cases involving imported foods found in violation of food hygiene standards. This will ensure the legality of future food trade between Oman and other countries, and will also enable Omanis to compete equally in international food trade activities and enhance the reputation of Oman's food products.
- Comprehensive legislation, adequate inspection and analytical services are keys to the success of any food control policy in providing an effective protection to the consumer. All of this depends upon an overall proper administration, capable of overseeing, programming and directing the food control activities. Whereas food control activities in the Sultanate of Oman are currently located in several different governmental agencies, the Food Safety Committee may serve as coordinating and planning body and the duties should be expanded to cover technical matters and serve as technical advisory body to the Government (Chapter Five). It would then be in a position to develop a system to be applied by all involved agencies to ensure harmony in inspection and analytical services, by developing manuals for inspection and analysis of food samples, especially

with regard to interpretation of analytical results, and also developing a draft for a new body of food legislation and keep current its provisions.

- Enforcement is necessary to encourage food industry members who refuse to, or ignore the need to, comply with legal requirements. All compliance policy statements should be in writing, widely promulgated, and should describe what action can be taken when violations are encountered. Strong measures, such as administrative fines, should be imposed on violators. Licence suspension or revocation or prosecution may be necessary in more serious situations (Chapters Four and Five). Since these stronger measures are usually subject to the purview of the judicial system, evidence of violations is needed and should be available to support the legal action. Food control officials should be prepared for these possibilities, and ensure that personnel are well trained in evidence gathering and secure handling of the evidence, to protect its integrity throughout the proceedings.
- A voluntary "Certification Mark Scheme" might be adopted. This scheme would be a third party quality assurance programme whereby manufacturers of good quality products would be awarded the certification mark of quality. This exercise needs to be employed by Government to encourage manufacturers to comply with set standards. In the food manufacturing sector, quality and safety of food would be promote through this scheme. The awards would trigger healthy competition amongst manufacturers of similar food products.
- Food safety education is a key factor in the success of food control. It is needed for all food operators in the entire food chain, from farm to consumption. The farmer handling agricultural chemicals or mishandling food during harvesting and storage needs food safety education (Chapters Four). The food industries

should be educated about GMPs., In addition, food safety education should be included as an essential part of nutrition and health education. Also, education should be done through the various public information services. This could be done via the service of the Ministry of Information, use of televisions, radios, newspapers and posters.

- Oman regulatory authorities should provide relevant information to the population generally on the safety of foods. The relatively low level of education of the greater part of the population is a major barrier to wider participation in food control activities. This is evident in fishing communities, and also probably applies to consumers as a whole. A Consumer Complaints Bureau might be established at the regulatory authority, so consumers can be made aware of such services and encouraged to participate as an approach to this issue. Consumers' rights and privileges under the food law can then be explained and people should be encouraged to notify food safety control officials of malfeasance, contamination of food and in sanitary conditions in food establishments.

- Training of food control personnel should be undertaken to emphasise the multi-disciplinary nature of food safety. After employment (with basic qualifications) food control personnel should be given on-job training which will include proper codes of conduct, a good understanding of food law and regulations and methods of enforcement, and also a good understanding of the objectives and purpose of food safety control (Chapter Eight).
- New requirements should be imposed, requiring that the owners of food businesses be responsible for ensuring that the people who handle food or food

contact surfaces in their business, and the people who supervise this work, have the skills and knowledge they need to handle food safely.

- Training institutions should include food safety control as a subject in their curriculum. Such a course will highlight the different aspects and factors affecting food safety and especially the effective and proper management of food safety programmes.
- The study reveals that fish processing companies confront many serious problems during the adoption and implementation of the HACCP system (Chapter Eight). Some of these problems can be solved with assistance provided by the Government, while others require a more serious and systematic approach by the companies. In order to overcome these problems, the government might establish an information office to give advice on all technical and legislation issues concerning safety and product quality. Directives on GMPs should be issued for each industry and product type. Fishermen and those involved in selling and handling should be brought up to date by establishing training institutions. Greater awareness of food safety issues might encourage improved controls at landing sites and fish markets in order to assure product safety at the purchase point.
- Some actions are also suggested for companies to carry out, to overcome problems during the adoption and implementation of the HACCP system. Companies should contribute to the development of directives of GMPs according to type of industry and product; each company should provide qualified personnel for this purpose; HACCP principles and philosophy should be incorporated into the company's culture; senior management should provide more financial support toward development of the HACCP plan and staff training. Staff

should be motivated towards proper and continuous implementation of HACCP through training programmes.

- One difficulty that affects the assurance of raw materials safety is the lack of good collaboration with suppliers (Chapter Eight). Raw materials, which are considered the weakest point in the food safety chain in Oman, are often exposed to serious hazards during their harvesting, handling and transport. Therefore, to overcome this problem, the researcher suggests that companies should be encouraged to collaborate with their suppliers. In order to overcome the difficulties associated with the safety of raw materials, the companies must adopt long-term working relationships with their suppliers in order to train them in GMPs, continuously check on the quality of their suppliers and operate complete controls during the handling procedure of raw materials, to detect any possible hazards at the company site in a short time, with the lowest possible cost.
- The findings of this study show that many managers in the fish processing industry have a limited understanding of the principles and application of the HACCP system (Chapter Eight). To realise the fullest potential of HACCP, its basic principles must be effectively communicated to fish business operators at all levels. It requires that a fish operator, understands the procedures used in handling and processing fish product(s), identifies and masters what must be controlled to make the product(s) safe, monitors important control points, corrects the system when there is a deviation, and verifies that criteria for control and monitoring are strictly observed in routine operations and keeps all important records.
- One way in which information on HACCP can be made widely accessible to fish business operators at this level is to build fish hygiene certification training

programmes around the HACCP system. This approach will in particular ensure that data on high risk hazards and preventive measures at critical control points are translated into training and education messages. The researcher recommends that HACCP training programmes should of necessity involve fish business operators in experiential activities and should include practical demonstrations of the HACCP principles. Provisions should also be made for consultation. Tangible examples should be provided of critical control points and of preventive and monitoring procedures with regard to specific types of processes, support materials, including model flow diagrams and literature must be provided. Achievement of the goals of HACCP training would probably be better enhanced if provided in-house, so that examples which are of direct relevance to specific processes in particular establishments could be given. The above recommendations are consistent with the findings of another study (Sumner and Albrecht, 1995) which evaluated implementation of food safety and HACCP training for small food processors in Nebraska, USA.

- Research institutes should be established, as they can play a vital role in providing the necessary data for policymaking and/or standardisation activities. Also, research activities should be properly coordinated and taken more seriously by the Government.
- The Government should encourage the industry to adopt HACCP which analyses potential hazards, identifies where such hazards can be controlled and describes the process parameters and their critical limits as well as monitoring procedures.
- There is a need for Government and industry to work in collaboration to provide food industry with appropriate epidemiological and scientific data to aid in identifying hazards, in conducting risk evaluation and in improving HACCP

plans. This requires accurate reporting, epidemiological surveillance and information related to the potential hazards in the food chain supply (Chapter Five). The absence of this information inhibits the implementation of effective food safety control measures and contributes to the failure of governments to commit the necessary resources to address the problems.

- If HACCP become mandatory across the food sector in Oman, the implementation of HACCP programmes needs to be carefully considered, planned and introduced over a reasonable period. Step-wise approaches to the implementation of HACCP have provided time for industries/sectors to adjust and have contributed to greater ownership of the results. HACCP implementation involves resource commitments by industry and new skills and responsibilities for employees. The implementation of HACCP based inspection programmes involves the commitment of regulatory resources, from initial programme design and consultation through to ongoing programme maintenance. In this regard, a food business is required to have a food safety programme; it must examine all of its food handling operations in order to identify those food safety hazards that might reasonably be expected to occur and prepare a written food safety programme to control these hazards. The programme must include controls for the identified food safety hazards, ways to monitor that the controls are working and steps to be taken when a hazard is not under appropriate control. Records must be kept by businesses to ensure that there is evidence that the business complies with the programme requirement. Finally, each food business should be regularly audited by a suitably qualified food safety auditor to ensure compliance, instead of an occasional inspection by regulatory authority to determine whether prescriptive requirements are being complied with. The auditor should be considered someone who assists a food business to identify possible hazards, controls and monitoring mechanisms.

- Poor access to information (regulations, standards, test methods etc) was noted at all levels, both in the government sector as well as industry (Chapters Five and Eight). The information presently available is diffused, located in various places and sometimes in personal collections. In this regard, setting up of a centralized reference library with accessibility to industry is strongly recommended.
- The regulatòry authority should be aware that there is no one HACCP programme that fits all regulatory requirements need to be clearly communicated to industry and regulators need to consult with and listen to feedback from all stakeholders as each HACCP application is unique industry needs to develop plant-specific HACCP systems that meet all regulatory requirements (Chapter Five)
- Regional co-operation and co-operation with other Arabian Gulf countries, especially those sharing similar experiences, can be very useful for exchange of ideas and experiences. In Asia and Latin America (PAHO, 1982) this is already happening. Countries in these regions meet regularly for conferences, workshops, seminars and other meetings to discuss problems and experiences common to the region. The.Gulf Co-operation Council states need to organise and meet regularly to discuss food safety and general food control matters affecting the region.
- Guidelines for the appropriate level of regulatory involvement and responsibility will be needed. This involvement could be as technical support for the design and application of HACCP plans; establishing a national programmes to ensure the quality, scientific validity and consistent application of HACCP systems; regulatory sanctions which may apply if an industrial sector does not take up

HACCP in a voluntary environment (i.e., where high-risk associated with their processing).

- Finally, a word of caution should be voiced here: establishing and upgrading food safety control systems is often a costly task. Oman has no other choice than to proceed step-by-step and to invest first where there is a serious need to guarantee compliance of their export products with international standards. However, domestic consumers should not be discriminated against, by having to eat food that is less safe than the food exported from their country. Food safety is the right of people everywhere.

9.3. Suggestions for further work

- In Oman, there are very low levels of consumer awareness of food safety hazards and a lack of consumer participation in matters affecting their health and economic well being including the right to safe and adequate food supplies. This can be achieved by developing studies to research further our understanding of consumer food safety knowledge and practices, consumer attitude and awareness towards food-related hygienic hazards and consumers risk perception of food products. More pressure from consumers may be expected to improve food safety service in Oman (as was the case in developed countries).
- Insufficient technical resources have been cited by many respondents in this study as one of the main barriers which prevents HACCP implementation. In the process of identifying hazards, the crucial issue is access to relevant background information on what the real hazards are for a particular product and process. Information from developed countries may not be relevant to the situation in a developing country.

Specific hazards in developed countries are normally identified through epidemiological studies, collation of consumer complaints, product alerts etc. In Oman, food processing industries have difficulty obtaining the scientific information necessary for developing sound hazard assessments, or for identifying specific support needed to implement HACCP. Databases on foodborne disease outbreaks, national food poisoning statistics, biological hazards and other reference materials are not readily available, or are non-existent. Such information is often not collated in Oman, as there is no central authority collecting and publishing information on reported outbreaks of foodborne illnesses. To overcome this constraint a further study should be conducted to develop a national database of hazards (biological, chemical and physical) indicating their occurrences and significance along the food chain supply.

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Appendix I

Interview questionnaire on the evaluation of HACCP implementation in fish processing establishments in Oman

1. Please tick the number that best describes your total volume of business (metric tonnes/year) for fish production and processing in 1999:

- ☐ Less than 10,000
- ☐ Between 10,000 and 20,000
- ☐ Between 20,000 and 30,000
- ☐ Greater than 30,000

2. Plant manager's length of service in the fish industry

- ☐ Under 10 years
- ☐ 10 - 19 years
- ☐ + 20 years

3. Quality controller's length of service in the fish industry

- ☐ 1 - 4 years
- ☐ 5 - 10 years
- ☐ 11- 15 years
- ☐ 16 - 20 years

4. Quality controller's level of food hygiene training

- ☐ Certificate
- ☐ Training
- ☐ No training

5. Number of staff employed

☐ Full-time (______________________________)

☐ Part-time (______________________________)

6. How many of the staff have the basic food hygiene certificate?

☐ Full-time (______________________________)

☐ Part-time (______________________________)

7. Is staff training documented?

☐ Yes

Evidence______________________________

☐ No

8. Do you have a training policy/target?

☐ Yes

Evidence

____

☐ No

9. If yes, what is this policy?

____

10. Do you have any external contract (s)?

☐ Yes

Evidence______________________________

☐ No

11. If yes, what are they for?

☐ Pest control

☐ Refrigerator/freezer maintenance

☐ Equipment maintenance

☐ Other (please specify______________________________)

12. Do you keep a record of actions (food safety/hygiene) by contracting firms?

☐ Yes

☐ No

13. How long is it since the inspection authority officer visited your food business premises? ____

14. What was the outcome of the visit?

☐ Oral improvement notice given

☐ Approval without conditions

☐ Conditional approval

☐ Written notice served

☐ Other (specify)____

15. What was (were) the nature of the issue(s) raised during the inspection?

☐ Structural
(specify____)

☐ Procedural
(specify____)

16. Have you ever approached the inspection authority for advice on issues relating to food safety?

☐ Yes

☐ No

17. Do you sometimes receive complaints from your customers?

☐ Yes

☐ No

18. What types of customer complaints do you receive?

____

19. Do you have a complaints logbook?

☐ Yes

☐ No

20. Do you check the raw materials/ingredients for safety on receipt from your suppliers?

☐ Yes

Evidence ______________________________

☐ No.

21. Do you take samples of the raw materials for microbial examination?

☐ Yes

Evidence ______________________________

☐ No.

23. Are records of these tests kept?

☐ Yes

Evidence ______________________________

☐ No.

24. Do you monitor the temperature of food/fish at any stage in your operation?

☐ Yes

Evidence ______________________________

☐ No.

25. Do you keep records of temperature?

☐ Yes

Evidence ______________________________

☐ No.

26. At which of the following stages do you monitor temperature levels?

☐ On receipt of foodstuff/fish and ingredients from suppliers

☐ During processing

☐ After freezing

☐ During cooling

☐ During cold holding/chilling/cold storage/freezing

☐ During delivery

☐ None of the above

27. Do you have a cleaning schedule?

☐ Yes

Evidence____

☐ No.

28. Is your cleaning schedule documented?

☐ Yes

☐ Evidence____

No.

29. Which of the following is a food safety rule of personal hygiene?

☐ Open cuts or wounds should not covered by dressings

☐ Clear fingernail polish is all right

☐ It is all right to use a toothpick while working

☐ You should wear no jewellery while you work

30. Which of the following is considered to be a good food contact surface sanitizer?

☐ Iodine

☐ Quaternary Ammonia

☐ Chlorine

☐ Phenol

31. Which of the following is best for cleaning and disinfecting the inside of the refrigerator/freezer/cold storage?

☐ Sodium bicarbonate

☐ Vinegar solution

☐ Bleach solution

☐ Odour-free bactericidal detergent

32. Smoking by food handlers in food handling area is to be discouraged because

☐ Food might absorb smoke flavours

☐ Smokers tend to cough over food

☐ Smokers touch their mouths with their fingers

33. All food products must be stored at least ____above the ground

☐ 15 cm

☐ 20 cm

☐ 30 cm

☐ 45 cm

34. Food poisoning bacteria can be passed on from

☐ Wild birds

☐ Rodents

☐ Insects

☐ All of the above

35. Which of the following terms have you heard of ? (Please tick (√) in the appropriate space)

	Heard of	Not heard of
Salmonella	______	______
Clostridium perfringens	______	______
Staphylococcus aureus	______	______
Carnpylobacter	______	______
Histamine .	______	______

36. Which of the following do you think is most likely to be spread by coughing and sneezing?

☐ *Salmonella*

☐ *Clostridium perfringens*

☐ *Spores*

☐ *Staphylococcus aureus*

☐ *Vibrio cholera*

37. During which of these occasions can cross contamination of food occur?

☐ When one infected food handler spreads the infection to other food handlers

☐ When bacteria transfer from raw to cooked food

☐ When bacteria transfer from cooked to raw food

☐ When rodents and insects transfer from one premise to another

38. At which of the following temperature levels will most food-poisoning bacteria multiply?

☐ -18° C to - 0 ° C

☐ 0 ° C to 20 ° C

☐ 20 ° C to 50 ° C

☐ 5 ° C to 63 ° C

39. The food safety danger zone is....

☐ 0 °C to 10 °C

☐ 10 °C to 20 °C

☐ 10 °C to 55 °C

☐ 5 °C to 63 °C

40. Why it is necessary to cool hot foods before refrigeration?

- ☐ To make cooling faster
- ☐ To prevent raising temperature of already stored food
- ☐ To prevent cross contamination

41. If only one refrigerator is available, which of these would you advise?

- ☐ To store cooked food (processed fish) above raw food (unprocessed fish)
- ☐ To store raw food (unprocessed fish) above cooked food (processed fish)
- ☐ To store only raw food (unprocessed fish) in the refrigerator
- ☐ To store only cooked food (processed fish) (processed fish) in the refrigerator

42. What is the correct operating temperature of refrigerator/cold storage?

- ☐ -18° C to -22 ° C
- ☐ 1 ° C to 5 ° C
- ☐ 12 ° C to 18 ° C

43. According to food safety principles, a freezer unit's temperature should be _____

- ☐ Cooler than -18 °C
- ☐ Cooler than -5 °C
- ☐ At 0 °C
- ☐ Less than 8 °C

44. Which of the components of International Standards Organisation (ISO) System have been introduced in your company?

- ☐ ISO 9000
- ☐ ISO 9001
- ☐ ISO 9002
- ☐ ISO 9003
- ☐ None of the above

45. What does HACCP stand for?

____

46. Have you received any information on HACCP?

☐ Yes

☐ No

47. Where from?

☐ Scientific journals

☐ Through Ministry of Agriculture and Fisheries

☐ External consultants

☐ Export needs

48. Do you have a HACCP plan for your business now?

☐ Yes

☐ No

49. If No, do you intended to have one?

☐ Yes

☐ No

☐ Not decided

50. If yes, how was it prepared?

☐ Prepared solely by private consultant(s)

☐ Prepared in-house with the assistance of private consultant(s)

☐ Prepared in-house with guidance of the authority

☐ Prepared in-house without external assistance

☐ Other (please specify____)

51. What are the steps involved in setting up a HACCP system?

Specify ____

52. What are the main hazards that need critical control points in your business?

Hazards____

53. Where are the CCPs in the process flowchart?

54. Are you adequately staffed to implement HACCP at present?

☐ Yes

☐ No

☐ I do not know

55. If No, what staff is needed?

Specify____

56. What is the most preferred HACCP training approach?

☐ Participation in the development of a HACCP plan

☐ Videotapes teaching HACPP plan

☐ Group discussion

☐ Workshops

☐ Information from regulatory officials

57. If HACCP implementation is made mandatory, what implementation procedure would you prefer?

☐ Ready to prepare and submit own HACCP plan for approval by the regulatory authority

☐ Would require assistance in identification of CCPs, development of monitoring and evaluation procedures, and preparing own plan

58. Which of the following contributes the major cost in implementing HACCP in your operation

(Please rank, in order of high cost, 1 = highest costs to 8 = lowest costs from 1 to 8)

☐ Developing HACCP Plan

☐ Consultants fees

☐ Training costs

☐ Hiring new employees

☐ Sanitation costs

☐ Laboratory analysis

☐ New equipment

☐ Plant modification and construction

59. How long it takes to make the HACCP system to be settle-down in your operation.

☐ 3 to 6 month

☐ 6 to 12 month

☐ 1 to 2 years

☐ more than 2 years

60. HACCP is a more effective safety control strategy than your current method or other method(s) you have used for ensuring food safety.

☐ Agree

☐ Undecided

☐ Disagree

61. HACCP can be used to support a defence of due diligence

☐ Agree

☐ Undecided

☐ Disagree

62. HACCP is an expensive strategy

☐ Agree

☐ Undecided

☐ Disagree

63. The HACCP strategy can be applied in my operation(s)

☐ Agree

☐ Undecided

☐ Disagree

64. HACCP is a time consuming strategy vis-à-vis the end benefit of its implementation

☐ Agree

☐ Undecided

☐ Disagree

65. Other comments

Appendix II

Semi-structure interview conducted in fish businesses in Oman

First stage: before HACCP implementation

- What type of quality management system did you use before adopting HACCP system in your operation?
- What are the main reasons that motivated your company to implement HACCP?
- Which of your departments were involved in the decision to implement the HACCP system?

Second stage: during HACCP implementation

The second group of questions concerned situations encountered during the implementation of HACCP.

- What was the total cost of your HACCP implementation?
- Can you analyse and divide the total cost of HACCP implementation into various categories?
- Do you have a HACCP team? And who is involved in it?
- How frequently do the members of the HACCP meet?
- What type of training did your company select for its employees in order to implement the HACCP system more effectively?
- How long did it take to get HACCP well settled into your working procedures?

Third stage: after HACCP implementation

- How has your company changed after full implementation of the HACCP system?
- To what extent have useless[1] products been reduced?

[1] low quality/safety of raw materials

Appendix III

Audit Checklist form used in assessing fish factories

FIXED INSTALLATIONS	A	B	C
FACTORY • Site (tidiness, pollution) • General design, lay-out, flow of goods • Separation between clean/unclean processing areas • Easy to keep clean • Maintenance			
EQUIPMENT • Sanitary installations and amenities (toilets, hand washing facilities etc.). Numbers, construction, position • Laboratory facilities • Water supply (quantity, quality (safe), hot, cold) chlorination Boxes and containers • Machinery • Waste disposal			
CHILLING/FREEZING CAPACITY • Ice supply • Chill room (numbers, size/capacity) • Freezers/frozen storage (numbers/size/capacity)			
OTHER REMARKS .			

VARIABLE FACTORS	A	B	C
RAW MATERIAL • quality, handling, control with –			
PROCESS/PROCESS-CONTROL • Flow, markings • Temperature/temperature control • Work routines (GMP/BMP), general tidiness • Process control, delegation of responsibility			
PERSONAL HYGIENE • Dress • General understanding of hygiene principles			
CLEANING AND DISINFECTION • Organisation of routine • Methods • Control with - .			
QUALITY ASSURANCE • Principles, organisation, delegation of responsibility • Staff • Monitoring of CCP's, records • Procedures for out of control situations			
OTHER REMARKS			

(A) Excellent, good or only minor deficiency

(B) Less good, serious deficiencies

(C) An unacceptable situation, which may result in an unwholesome product representing health of safety threats.

System Audit Checklist Reference

Structure and layout

Reason:

Care must be taken to not allow contamination to enter a food product through non direct means. This usually requires observation around food production areas and planning ahead. Improperly maintained outside conditions can cause contamination to enter the plant through a variety of means, such as airborne (wind), foot traffic, etc. In addition, improper layout of operations within a facility can inadvertently adulterate or contaminate the food product through employee traffic, wind drafts, or other means.

Ground condition can permit contamination to enter the facility

Compliance:

There shall be no conditions on the grounds such as dusty roads or parking lots, mud puddles, chemical spills, etc., that can cause contamination to be carried into the plant through such means as wind drafts, personnel foot traffic, adherence to personnel clothing, flooding, etc. Design of the facility structure should be such that access is easily obtained to all areas. This is necessary for proper cleaning and sanitizing of floors, walls and ceilings, as well as for visual inspections.

Facility

Design, layout of material used cannot be readily cleaned sanitized; does not preclude product contamination or adulteration

Compliance:

If the rooms in the facility are lay out or designed in such away that they cannot be readily cleaned or sanitized then the facility is not in compliance. This would include improper materials for walls, ceilings etc., as well as hard to reach rooms or corners even when the equipment is removed from the room.

Insufficient separation by space or other mean allows product to be adulterate or contaminated

Compliance:

There must be sufficient separation between different activities in the possessing, packaging and handling of food products. The food product should flow easily from one stage to another and not be allowed to come into contact with non-food surfaces if exposed. In addition, the layout of the facility should not be such that product contamination is likely due to heavy employee traffic through work areas.

Retail product displays should be arranged so that there is sufficient separation to assure that no cross contamination can occur between raw, cooked, and live product.

Maintenance

Reason:

Food handling establishments must be maintained a: a high level. Deterioration of the building such as a leaky roof, cracks or depressions in the floor, or unprotected glass lighting fixtures can be reservoirs for bacteria or can cause direct contamination of food products being manufactured in the facility. Equipment and utensils which are not well maintained also pose a risk of bacterial harbourage or direct product contamination. Conditions such as rusted or pitted product conduct surfaces and frayed conveyor belts are examples of non compliance.

Condition of roof, ceilings, wall, floor, or lighting not maintained light not protected

Area directly affecting product or packaging material.

Compliance:

For those areas which will directly affect product or primary packaging materials, (packaging immediately surrounding product), the roof, ceiling, walls, floors and lighting fixtures must be maintained as deigned and light must be protected. Failure to do so causes the facilities to be out of compliance.

Other.

Compliance:

For areas in the facility other than in 3.1.1 above the roof, ceilings, walls floors or lighting fixtures must also be maintained as designed. This does not include those areas designed as offices and in which food products or primary packaging materials in any stage of production will no be handled or stored.

Insufficient lighting

Compliance:

Lighting in areas where food is handled, processed, stored, packaged, or displayed and where sanitation is performed must be adequate to allow the intended operation to be performed in a sanitary and wholesome manner. Lighting of the display should not be so excessive as to affect the temperature of the product.

Equipment and utensils not maintained in proper repair or removed when necessary.

Product contact surfaces

Compliance:

All product contact surfaces must be kept in good repair. If the contact surface cannot be repaired, then the piece of equipment or utensil should be removed so as not to allow for its use. Failure to provide these conditions will result in non-compliance.

Other.

Compliance:

All non-food contact surfaces should also be maintained in good repair. The facility is in non-compliance when the maintenance of all additional equipment or areas of equipment and utensils not referred to in item

Water supply

Reason:

Process water must be of very high quality as it directly interfaces or becomes part of the product being manufactured. Therefore, no filth, deleterious chemicals, bacteria or other contaminate may be present in solution as it will directly affect the safety of the product. Available water must pass portability standards established by Federal, State and local authorities. Water that is supplied to the plant must meet certain minimum standards. However, processing water must also be reasonably protected in the facility. Conditions that allow contamination to occur cannot be allowed. These may include cross-connection of plumbing, back siphonage or back flow from a contaminated source to the supply system or open vessels of water.

Unsafe water supply

Compliance:

The water supply will be in compliance when certification or direct testing the supply is found to meet the federal standard set forth by the Environmental Protection Agency. Private supplies shell have testing performed a minimum of every six (6) months. Certification of municipal or community systems should be secured at a minimum of once per year.

No protection against backflow, back-siphonage, or other sources of contamination

Compliance:

A facility will be in compliance when all cross-connections are eliminated, backflow prevention devices are installed wherever backflow or siphonage may occur or where other possible forms of contamination may be present.

Inadequate supply of hot water

Compliance:

Hot water is necessary for many cleaning techniques. In Addition, a hot water supply is necessary to provide a comfortable means for employees to wash their hands. If the tap is on and a luke-warm supply of water is present in sufficient quantities for the tasks it will perform in the facility, the plant is in compliance.

Ice

Reason:

Due to its close proximate use to fishery products, ice should be considered a product contact surface as well as a possible product constituent that could impart filth or contaminants to the food. Therefore, ice should be made from safe potable water and be handled the same manner as a food product.

Not manufactured, handled, or used in a sanitary manner

Compliance:

A facility will be in compliance when potable water is used for manufacturing, when the manufacturing equipment is clean and the ice only touches impervious surfaces; the ice holding containers are clean and made of appropriate impervious material; handling equipment is clean and appropriate for food contact; ice is not reused on ready-to-eat product. For facilities receiving ice from an outside supply, a certificate of conformance will be necessary co ensure that the ice being received meets the standards set forth in this document. In addition, portability checks must be made at a minimum of every six (6) months on ice received.

Control.

Facility management doe not have effect measures to restrict people with known disease from contaminating the product.

Compliance:

No person affected by disease in a communicable form, or while a carrier of such disease, or while affected with boils, sores, infected wounds, or other abnormal sources of microbiological contamination, shall work in a food plan: in any capacity in which there is a reasonable possibility of food or food ingredients becoming contaminated by such person. Plant management shall require employees to report illness or injury to supervisors.

Hand washing and hand sanitizing stations not present or conveniently located.

Compliance:

Hand washing and hand sanitizing stations must be presented and located conveniently and in sufficient numbers to provide employees ease of their use.

Personnel

Reason:

A high degree of personnel compliance is necessary for a sanitation program to work properly. The best systems can easily be defeated if the facility personnel do not maintain high ideals in the production and handling of the food product.

Processing or food handling personnel do not maintain a high degree of personal cleanliness. Compliance:

All persons, while in a food preparation handling areas shall wear clean outer garments, and conform to hygienic practices while on duty, to the extent necessary to prevent contamination or adulteration of food. This includes occasional workers or visitors to the area.

Processing or food handling personnel do not take necessary precaution to prevent contamination of food.

Compliance:

All persons, while in a food preparation or handling area.

- Wash their hands thoroughly to prevent contamination by undesirable microorganisms before starting work, after each absence from the work station, and at any other time when the hands may have become soiled or contaminated. After washing the hands must be sanitized using the company provided hand dip stations.
- Remove all insecure jewellery and when food is being manipulated by hand, remove from hands any jewellery that cannot be adequately sanitized.
- If gloves are used in food handling, maintain them in an intact, clean, and sanitary condition. Such gloves shall be of impermeable material except where their usage would be appropriate or incompatible with the work involved. If gloves are used they will be washed and sanitised at the same frequency as employees hands as described in number one of this list.
- wear hair nets, caps, masks, or other effective hair restraint. Other persons that may incidentally enter the processing areas shall comply with this requirement.
- Not expectorate; nor store clothing or other personal belongings not eat food or drink beverages; nor use tobacco in any form in areas where food or food ingredients are

exposed or in areas used for food processing, storage of food ingredients and/or packaging materials, washing of equipment and utensils or in production areas.

- Take other necessary precautions to prevent contamination of foods with microorganisms or foreign substances including, but not limited to perspiration, hair, cosmetics, tobacco, chemicals, and mendicants.

Cleaning and sanitation

Reason:

A sound cleaning and sanitizing operation is vital to plant and food hygiene. Product contact surfaces are most important and the most obvious. However, improper cleaning of non-product contact surfaces can cause adulteration or contamination to occur through indirect means. In addition, good housekeeping of all areas including employee locker rooms and restrooms is necessary to allow the inspector proper observance of rooms and areas to determine if they are in fact clean.

Product contact surfaces not cleaned or sanitized before use.

Compliance:

Product contact surface must be cleaned using proper techniques to remove direct debris. Sanitizers must be used before product contacts the surface. Sanitizing without cleaning is insufficient. Any violation will be considered non-compliance.

Non-product contact surface not cleaned before use

Compliance:

Non-product contact areas must also be cleaned prior to use. However, sanitizing is not required. This includes wall, ceilings, floors and other room areas as well as equipment.

Inadequate housekeeping.

Compliance:

Any excess clutter in product areas, employee areas, or other areas of the facility will cause the facility to be in non-compliance. This does not include those areas designated as office areas.

Pest Control

Reason:

The presence of rodents, insects, and other animals in the facility should not be allowed because they are sources for the contamination of food with extraneous material, filth and bacteria etc.

Harbourage and attractant areas present

Compliance:

The facility and grounds are free of harbourage areas. These include but are not limited to: uncut weeds, brush or tall grass; improper storage of unused equipment or materials; presence of litter, waste and refuse; or standing or stagnant water.

Pest control measures not effective

Exclusion

Compliance:

Openings to the outside of or within the facility may allow vermin or other pests to enter. Openings and cracks should be screened or otherwise sealed. Screens must be of a mesh no: larger than 1/16th of an inch in order to exclude insects. Cracks or holes should be sealed and doors and windows should close tightly (no opening large than 1/4th inch) to exclude rodents or other animals. Air curtains and strip curtains must be effective. Strip curtains must run the entire width of the opening with sufficient overlap between flaps (1/2 inch). In addition, every effort should be made to keep birds from areas of the plant where food is transferred or processed.

Extermination

Compliance:

Bird nesting areas must be eliminated.

Insect: There should not be a significant number of insects present in the facility. Insect electrocution devices, when used, must be located near the entranceway. Approved insecticides should be used whenever insect populations become noticeable.

Rodents--Evidence of rodents includes fecal droppings present, urine stains on bags or walls, slide marks along rodent runways, feeding areas around stored dry goods bags and are excessive, or the facility does not have appropriate rodent control measures in place, the facility is not in compliance.

Equipment and utensils' deign, construction, location, or material cannot be readily cleaned and sanitized doe not preclude product contamination or adulteration

Compliance:

Any equipment used in the manufacturing or handl1ng of the food product must be designed or constructed so that it can be easily taken apart for regular cleaning and inspection. Failure to do so will cause the facility to be out of compliance. In add1tion, if the materials used are not of a material suitable for its intended purpose or there is reuse of single-service items, then the facility is also out of compliance.

Restrooms

Reason:

Sufficient restroom facilities and restroom supplies not only provide for the comfort of employees but are nècessary for good healthy and wholesome conditions for the production of food.

Insufficient number of functional toilet

Compliance:

The facility must have one operable toilet per fifteen (15) employees, per gender. For men, urinals may be substituted for toilet bowls, but only to the extent of one-third (1/3) of the total number of bowls required.

Inadequate supplies

Compliance:

The restrooms must provide supplies such as toilet paper, soap, etc., sufficient enough to meet employees needs.

Chemicals

Reason:

Plant chemicals are cleaners, sanitizers, rodenticides, insecticides, machine lubricants etc. They must be used according to manufacturer's instructions, have proper labelling and be stored in a safe manner or they may pose a risk of contaminating the food product that the establishment is handling or manufacturing.

Compliance:

A facility will be in compliance when the chemicals are used according to manufacturer's instructions and recommendation and stored in an area of limited access away from food handling or manufacturing. All chemicals must be labelled to show the name of the manufacturer, instructions for use, and the appropriate EPA or USDA approval:

9.1 Chemical(s) improperly used or handled.

9.2 Chemical(s) improperly labelled.

9.3 Chemical(s) improperly stored.

Ventilation

Reason:

The lack of proper ventilation in a facility may cause condensation or foul odours to occur. Both are due to inadequate air exchange in the building. Condensation in a plant environment may cause filth, bacteria or other contaminants to adulterate food products through drippage on exposed food, processing equipment or packaging material. Foul odours normally reveal the presence of bacterial activity within the plant.

Condensation

Areas directly affecting product or primary packaging material

Compliance:

If any condensation is found in areas in the facility where the condensation has the potential to come in contact with product or primary packaging material, the facility is in non-compliance.

Other

Compliance:

Any areas other than those noted above where food is stored, handled. Processed, packaged, or displayed shall be condensation-free. If condensation is noted in these areas, the facility shall be in non-compliance.

Adequate air exchange doe not exist.

Compliance:

A facility is in compliance when adequate air exchange exists to preclude the development of foul odours.

Waste Disposal

Reason:

In a manufacturing environment raw material is either utilized in the product or is discarded as waste which may be eliminated via the sewerage system or physically removed. Sewage should be regarded as anything that accesses the sewerage system including bodily wastes, gurry and process water etc. Any failure to eliminate these wastes allows fecal and other human disease organism to possibly contaminate the food product through splash, foot traffic or other means. Processing Waste is likely to carry filth, decompose quickly and be an attractant to rodents, insects and other vermin.

Improper disposal of

Sewage

Compliance:

A facility is in compliance when sewage systems drain properly are vented to the outside and are connected to an approved private septic system or a public septic system.

Processing waste

Compliance:

A facility is in compliance with regard to processing wastes when they are placed in proper containers, placed at appropriate locations throughout the plant and removed frequently.

Appendix IV

Recommendations to Improved Fish Markets in Oman

A. Design Requirements For Fish Markets

- Must be covered, and have walls which are easy to clean.
- Have waterproof, preferably tile, flooring which is easy to wash and disinfect.
- Must have drains in floors, which are laid in such a way as to facilitate water drainage.
- Must have a hygienic waste disposal system.
- Must be equipped with sanitary facilities with washbasins and lavatories.
- Must have a separate area, other than the selling area, for cutting fish. This area must be enclosed and constructed of walls and floors that are easily cleaned and floors with suitable waste drainage. Fish should be cut on tables, not on the floor, and waste storage bins should be covered. Wood boards should not be used for cutting fish.
- Must have a supply of ice at or readily accessible adjacent to the market.
- Must have an adequate supply of potable water.
- Must be enclosed, capable of keeping out insects and pests, and air conditioned if possible.
- Must be cleaned regularly, and after each sale, boxes must be cleaned with potable water before reuse and, where required, sanitized.
- Persons selling the fish shall have a health certificate and must be licensed in accordance with requirements set forth by the Ministry of Agriculture and Fisheries.

B. Recommended Code of Practice

- Cleanliness is of primary importance for quality. All surfaces with which the fish comes into contact, such as floors, boxes, cutting and filleting boards and utensils should be kept clean, so as to minimise contamination by spoilage bacteria. All such utensils and equipment should be cleaned thoroughly at the end of each working day, and moveable equipment stored in a clean place.

- Sinks and cleaning troughs should be kept thoroughly cleaned at all times, should be constructed of impervious material, should have a smooth, even surfaces, and should be without any sharp angles.
- Fish is more delicate in texture than meat and it is particularly important not to bruise, crush or tear it. To do so not only spoils the appearance of the fish but causes softening and allows bacteria to spread into it. Walking or trampling on fish, or trailing or throwing it should be avoided. Where the use of sharp hooks or other instruments liable to pierce and tear the flesh is necessary, they should not be inserted in any other part of the fish except the head and gills.
- Running potable quality water should be used for cleaning fish. If running water is not readily available, the washing water should be frequently changed. All washing water should be kept cool, as close to 2-3 C as possible. Clean, crushed ice made from potable water may serve as a convenient cooling agent when running water is not used.
- Fish for filleting or cutting into steaks should be thoroughly washed. Fillets should be iced or processed immediately after cutting.
- As bacterial penetration through cut surfaces of fish is more rapid than through fish flesh protected by skin, all utensils and equipment used for filleting should be checked at the beginning of the working period to see that they are clean, and thoroughly cleaned when the work is finished using hot water, detergent, and a suitable sanitising agent.
- Temperature is the most important factor affecting the quality of wet fish, and the lower the temperature, the slower the rate of spoilage. All wet fish should be maintained at a temperature as near as possible to O C (32 F) from the time of landing through sale and preparation for cooking by the customer.

C. Recommended Hygiene Practice

- Knives and other cutting utensils should be constructed of steel, with stainless or polypropylene handles. Wooden handles are unsatisfactory.
- Cutting and filleting boards should be of the non-absorbent synthetic variety, such as polypropylene. Hard wood chopping boards are permissible but must be maintained in a good condition.
- Tanks in which fish is washed, counters, slabs, and preparation areas should be cleaned daily by washing and scrubbing with a hot detergent solution, sanitised

with a compatible sanitizer, and rinsed with clean water. A combined detergent sanitizer used to manufacturer's instructions is also suitable.

- Equipment and utensils should be thoroughly washed at least once daily in hot water containing caustic soda, or some other suitable detergent and afterwards rinsed in hot water {minimum 77 C) .If a sanitising agent is used as well as a detergent in the washing water, the temperature of the water may be reduced.
- The Communicable Diseases Control Section of the Ministry of Health must medically examine food handlers prior to initial engagement and at least annually. Valid certification that fish handlers have been medically examined and are fit to handle food is required by law.
- Food handlers suffering from or otherwise affected by any medical condition known to affect the safety of food handling must be suspended from food handling duties until the condition is completely cleared. It is the duty of any food handler to notify his employer and/or doctor if he is suffering from diseases.
- Any cuts, scalds, burns or similar condition on the hands, or forearms must, until the condition has healed, be covered with clean waterproof dressings with sealed edges.
- Food handlers must bath and change their clothing frequently. Full protective clothing (to include head coverings) must be worn, and changed as soon as obviously soiled, one day's wearing ideally being the maximum.
- Fish handlers must keep their hair and finger nails clean and trimmed.
- Fish handlers must not eat, drink, spit, smoke, chew tobacco, use snuff, pick their noses or ears, or lick their fingers in food areas.
- Fish handlers must not cough or sneeze over food.
- Fish handlers must wash their hands: before starting fish handling, after using a water closet, after using a handkerchief, combing their hair, or touching other parts of their bodies (e.g. noses, mouths, eyes, and ears), before handling cooked foods and particularly after handling raw foods, after eating or drinking, after handling dirty equipment, particularly refuse bins,
- Fish handlers must not wear watches or jewellery other than wedding rings.

Suitable and sufficient facilities in the form of wash-basins or troughs must be provided in convenient position for the use of fish handlers. A supply of hot and cold water or water at a suitably-controlled temperature must be provided to basins or troughs, and the latter shall have trapped waste pipes connected to an effective drainage system. A supply of soap (preferably bactericidal), nail brushes (plastic with nylon bristles and clean towels or other means of drying shall be provided to the basins.

Appendix V

A checklist form used for the assessment of HACCP manual

Component to assess	Mi[a]	Ma[b]	Observation(s)
(1) Commitment of the management Moral commitment . Financial commitment Awareness/conviction **(2) HACCP team** The HACCP team leader has effective power of decision The HACCP team members are qualified **(3) Composition of products** Food composition is reflective of the one described in the manual Any modification is recorded and taken into account for HACCP revision **(4) Intended use** Valid description of the intended use Any modification is recorded and taken into account for HACCP revision **(5) Process flow diagram(s)** The flow diagram description is always valid Any modification is recorded and taken into account for HACCP revision **(6) Hazard analysis** All control measures are correctly implemented Personnel in charge of control measures are identified and qualified New hazards, introduced because of changes in product, process,...were taken into consideration Control measures have been identified for these hazards **(7) Critical control points** CCP are conform to those described in the HACCP manual Introduction of new hazard has resulted in CCP analysis to implement proper control measures **(8) Critical limits,,** Critical limits are conform to those described in HACCP manual Introduction of new hazard has resulted in the revision of the critical limits **(9) Monitoring procedures** Monitoring procedures are conform to those described in the HACCP manual The reliability of the monitoring procedures has been validated Personnel in charge of monitoring is well identified and trained All necessary modifications have been made to take into account the introduction of new control measures.			

(10) Corrective actions			
Corrective actions are conform to those described in the HACCP manual			
Personnel in charge of corrective actions has been identified and trained			
All necessary modifications have been made to take into account the introduction of new control measures			
(11) Verification of the HACCP system			
The method and frequency of verification are conform to those described in the manual			
The validity of the verification method has been confirmed			
Personnel in charge of verification is identified			
Changes of products, processes, standards, regulations,...were taken into consideration			
(12) Record-Keeping System			
Forms are as described in the manual			
Forms are up to date for recording:			
Monitoring results,			
Corrective actions,			
Modifications of the HACCP system			
HACCP Verification/revision results			
Some records have been tempered with			

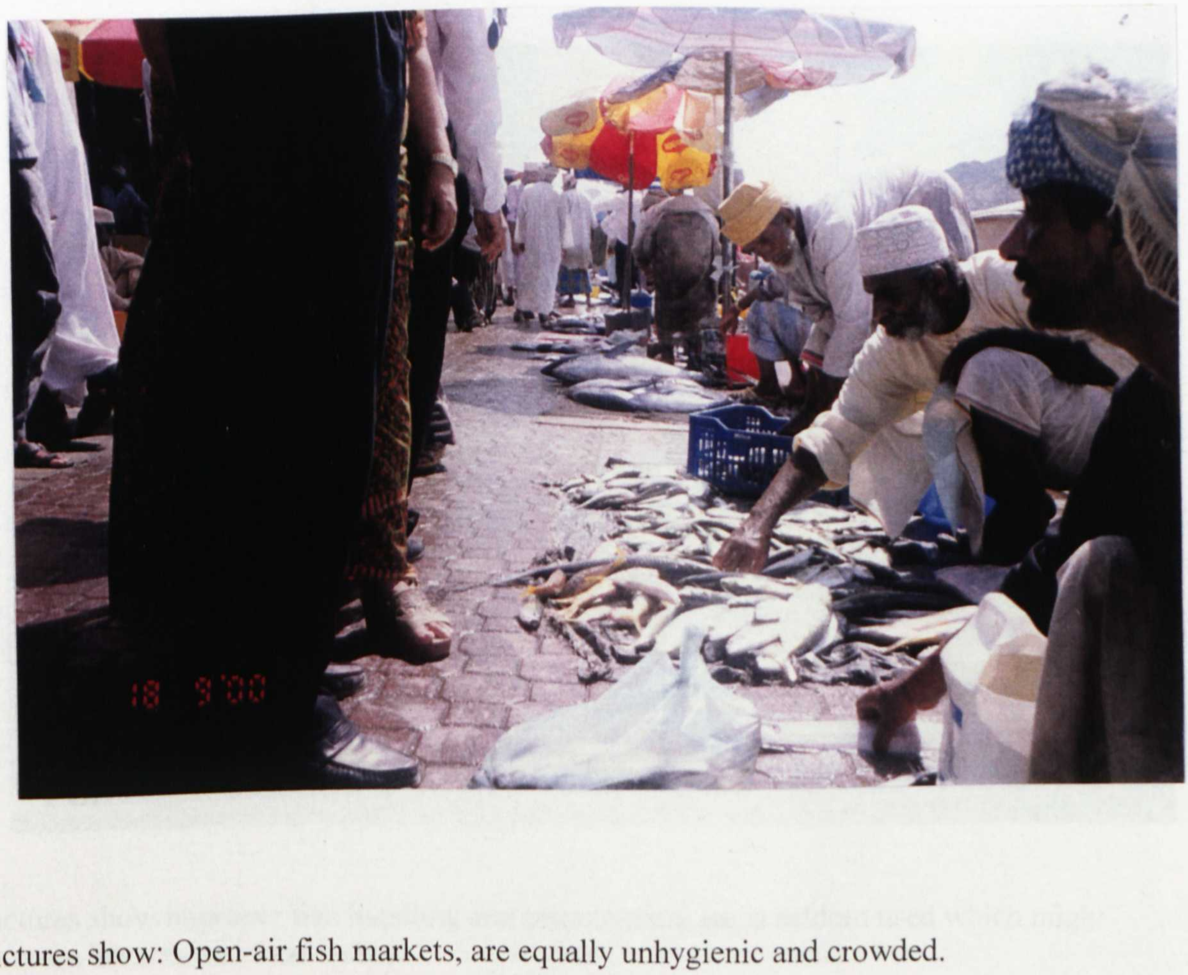
[a]*Mi: minor non-compliance*: this refers to isolated cases within a given element of the HACCP system and which will not have any noticeable effect on the control of food quality and safety.
[b]Ma: Major non-compliance: this refers to the absence or the failure of an element of the HACCP system. Repetitive or cumulative minor deficiencies can lead to major non-compliance situations.

Appendix VII

Photographs illustrate problems in food chain supply in Oman

Pictures show improper presentation of fish, increases foodborne hazards. Fishing may be conducted improperly and unethically.

Pictures shows: Unhygienic fish cleaning areas increases foodborne hazards.



Pictures show: Open-air fish markets, are equally unhygienic and crowded.

PAGE MISSING IN ORIGINAL

Pictures show improper fish handling and presentation, ice is seldom used which might increase hazards and food losses.

Transportation is one of a major constraint in fish distribution. In some cases, old dilapidated and unhygienic truck are used to transport (see picture below)

Appendix VII

Common Microbes Found in Food and Water

Bacillus Cereus (Bacillus)

Onset:	8 to 16 hours.
Symptoms:	Abdominal pain, watery diarrhea, vomiting and nausea.
Associated Foods:	Meat products, soups, vegetables, puddings and sauces, milk and milk products.
Prevention:	Cook foods thoroughly, properly reheat food during preparation, and prevent cross contact.

Campylobacter jejuni (Campylobacter enteritis)

Onset:	1 to 7 days.
Symptoms:	Nausea, abdominal cramps, diarrhea, and fever Associated Foods: Raw milk, poultry, raw beef water, and pets.
Prevention:	Use pasteurized milk; cook foods thoroughly; prevent cross contact; use sanitary practices; wash hands after handling pets.

Oostridium botulinum (Botulism)

Onset:	18 to 36 hours after ingestion of the food containing the toxin, although onset times have varied from 4 hours to 8 days.
Symptoms:	Nausea, vomiting, diarrhea, fatigue, headache, dry mouth, double vision, droopy eyelids, muscle paralysis, trouble speaking and swallowing, difficulty breathing. Fatal in 3 to 10 days if not treated.
Associated Foods:	Under processed low-acid canned foods (such as green beans. mushrooms and tuna fish) and vacuum packaged meats, sausage, and fish.
Prevention:	When canning foods, follow recommended procedures; cook foods / properly. Refrigerate packaged meats and fish.

Oostridium perfringens (Perfringens food poisoning)

Onset:	8 to 22 hours.
Symptoms:	Diarrhea, abdominal cramps, headache and the chills.
Associated Foods:	Meat, poultry, stuffmg, gravies and cooked foods held for serving or stored at inappropriate temperatures.
Prevention:	Cool foods rapidly after cooking; hold hot foods at 140°F or above. Reheat foods at 165°F.

Cryptosporidium parvum (Intestinal, tracheal or pulmonary cryptosporidiosis)

Onset: Approximately 2 days

Symptoms: Intestinal cryptosporidiosis is characterized by severe watery diarrhea, no symptoms at all. Pulmonary and tracheal cryptosporidiosis is characterized by coughing and low-grade fever often accompanied by severe intestinal distress.

Sources/Associated Foods: Could occur on any food touched by an infected food handler. Incidence is higher in child day care centers that serve food. Salad vegetables could be a source if fertilized with contaminated manure or irrigation water. Outbreaks are often linked to contaminated water supplies.

Prevention: Use properly treated water. Note that water must be filtered to remove this microbe; chlorine does not kill it.

Cyclospora Cayetanesis (Cyclosporidiosis)

Onset: One week.

Symptoms: Explosive and watery diarrhea, accompanied by fatigue, nausea, vomiting, muscle aches, low-grade fever, abdominal cramping, 1088 of appetite, myalgia, and substantial weight loss. Some people who are infected with Cyclospora do not have any symptoms.

Associated Foods: Food or water contaminated with infected stool.

Prevention: Avoid water or food that may be contaminated with stool.

Escherichia coli (E. co/i) 0157:H7 (Hemorrhagic Colitis)

Onset: 2 to55 days.

Symptoms: Severe abdominal cramping and diarrhea which is initially watery but becomes grossly bloody. Occasionally vomiting occurs. Fever is either low-grade or absent. Some individuals exhibit watery diarrhea only.

Associated Foods: Raw or undercooked ground beef; raw milk some fresh produce, unpasteurized apple juice, alfalfa and radish sprouts.

Prevention: Cook meat to appropriate temperature; avoid cross contact; use sanitar practices; drink pasteurized milk and apple juice.

Hepatitis A Virus (HAV) (Hepatitis)

Onset: 10 to 50 days (mean 30 days).

Symptoms:	Mild illness characterized by sudden onset of fever, malaise, nausea, anorexia, and abdominal discomfort, followed by jaundice.
Associated Foods:	Foods contaminated by HAV infected workers in food processing plant or restaurants. Cold cuts and sandwiches, fruits and fruit juices, vegetables, salads, and shellfish are commonly implicated in outbreaks. Water, shellfish, and salads are the most frequent sources.
Prevention:	Use sanitary practices; avoid eating raw shellfish.

Listeria monocytogenes (Listeriosis)

Onset:	2 days to 3 weeks.
Symptoms:	Fever, nausea, vomiting, and diarrhea may precede more serious forms of listeriosis or may be the only symptoms expressed. More serious manifestations of listeriosis include meningitis, septicemia (infection in the blood).
Associated Foods:	Improperly refrigerated milk, raw vegetables, soft or semi-soft cheese, pate, deli meat, poultry, seafood. Can grow slowly at refrigerated temperatures.
Prevention:	Cook foods to appropriate temperatures; avoid cross contact; use sanitary practices; do not store foods in the refrigerator for long periods of time; keep the inside of refrigerators clean; irnmunocompromised individuals should avoid eating high risk foods such as soft cheeses and pate.

Norwalk Virus (Viral gastroenteritis, acute non-bacterial gastroenteritis, food poisoning and food infection)

Onset:	24 to 48 hours.
Symptoms:	Nausea, vomiting, diarrhea, and abdominal pain. Headache and low-grade fever. Severe illness or hospitalisation is very rare.
Sources/Associated Foods:	Untreated water from municipal supplies, wells, recreational lakes, swimming pools, and that stored aboard cruise ships is the most common source of outbreaks. Shellfish and salad, raw or insufficiently steamed clams and oysters. Foods other than shellfish may be contaminated by infected food handlers.
Prevention:	Avoid raw shellfish; use sanitary practices.

Salmonella species (Salmonellosis)

Onset:	6 to 48 hours

Symptoms:	Nausea, vomiting, diarrhea, abdominal cramps, fever, headache and chills. Arthritic symptoms may follow 3-4 weeks after onset of acute symptoms.
Associated Foods:	Raw or undercooked meats, poultry, eggs, milk and dairy products, shrimp, frog legs, non-commercial sauces, salad dressing, cream-filled desserts and toppings made with raw eggs, cocoa, chocolate, and alfalfa sprouts.
Prevention:	Cook foods thoroughly; avoid cross contact; use sanitary practices.

Shigella species (Shigellosis)

Onset:	12 to 50 hours.
Symptoms:	Abdominal cramps; diarrhea with blood, pus, mucus; fever; vomiting; chills.
Associated Foods:	Salads potato, tuna, shrimp, macaroni, and chicken, raw vegetables and untreated water. Foods usually are contaminated by an infected food handler.
Prevention:	Use sanitary practices; avoid cross contact; cook foods thoroughly; store foods at proper temperatures (cold foods at 40°F or below; ho foods at 140°F or above).

Staphylococcus aureus (Staphylococcal food poisoning)

Onset:	1 to 6 hours
Symptoms:	Severe nausea, vomiting, diarrhea, abdominal cramping.
Associated Foods:	Found in humans (skin, infected cuts, pimples, noses, and throats) and frequently transmitted to foods by human carriers. Foods associated with outbreaks include, custard- or cream-filled baked goods, ham, tongue, cooked poultry, dressing, gravy, eggs, potato salad, cream sauces, sandwich fillings.
Prevention:	Use sanitary practices; refrigerate foods

Vibrio vulnificus (Vibrio infection)

Onset:	Abrupt
Symptoms:	Chills, fever, and/or prostration. People with liver conditions, low stomach acid (elderly), and weakened immune systems are at high risk. Symptoms include vomiting, diarrhea, and abdominal pain, rapidly followed by fever and chills.

Associated Foods:	This bacterium lives in coastal waters and can infect humans either through open wounds or through consumption of contaminated seafood (clams, oysters, scallops, crabs and finfish).
Prevention:	The organism is easily killed by cooking; avoid eating raw shellfish, especially oysters.

Yersinia enterocolitica (Yersiniosis)

Onset:	1 to 3 days
Symptoms:	Enterocolitis (inflammation of the intestines and colon) with diarrhea and/or vomiting; fever and abdominal pain are the typical symptoms. May mimic acute appendicitis.
Associated Foods:	Pork and raw milk.
Prevention:	Use pasteurized milk; cook foods to proper temperatures; avoid cross contact; use sanitary practices; avoid storage of foods in the refrigerator for long periods of time.

Appendix VIII

Summary of Economic Survey

The data in Table are a summary of data collected by the researcher. 12 companies were requested to supply commercial data for the calendar year 1999 about their operations. Many companies were reluctant to supply data, and there must be some doubt about the accuracy of all of it. However, it was felt useful to present it as part of the results of the research. There is no official obligation on companies in Oman to supply detailed management accounting data of the type listed.

The columns are as follows:

1. Company. 12 companies supplied commercial data, with some obvious omissions in the data set.

2. These are the estimated annual purchases by the surveyed companies.

3-5. These three columns give the companies' estimates of the proportionate division of their sales between domestic wholesale, domestic retail and export. Exporting is evidently dominant.

6-10. These are the reported operating costs supplied by companies, and column 10 is the total of these.

11. This the depreciation charge reported by companies.

12. These are the HACCP development costs. This means the costs reported by companies on physical infrastructure-buildings and equipment-for HACCP implementation.

13. These are reported HACCP operating costs.

14. These are the sums of the various cost estimates.

15. These are the reported values of sales. In the case of company 1 the sales are estimated using the volume of purchases and the average sales price for company 10, which is a similar company.

16. These are the annual profits estimated from data supplied by the companies.

17. These are the companies' own estimates of their cost increases as a result of HACCP.

18. The "economic added value" is an attempt to give a preliminary estimate of the returns of HACCP implementation to Oman, and is estimated by simply adding labour costs to profits for each company, thus roughly estimating how much gain, in terms of addition to national income, the country gets from HACCP.

19. This is the reported number of employees.

20. This is a measure of productivity – although the volume of fish purchased is used as the numerator as a substitute for "output".

21. These are reported wage costs per employee.

The main conclusions are:

- HACCP development was expensive for all companies surveyed, mainly because it required the purchase of new equipment as well as alterations to buildings (see Chapter Five).
- HACCP operating costs, excluding the investment costs, seem to be very low, almost a cost which companies have been able to take in their stride.
- The difference between the regional price in the Gulf ($1.17/kg) and the EU price ($1.85/kg) is an approximate indication of the relative gain per kg of HACCP implementation, since, without

HACCP, the companies would be selling fish into the regional market. Price data are from Table 8-7 page 159, Statistical Year Book (2002), Ministry of Development Sultanate of Oman.

- Companies have shown themselves willing to invest, and therefore perceive HACCP implementation as profitable, a conclusion borne out by the estimates (based on company-supplied data) of EAV and profits per kg ($0.83 and $0.58 respectively), even after substantial depreciation charges.

Appendix VIII. Summary of Economic Survey

RO/$ exchange rate 0.3851633 Average $ value of fish

(All costs in USD)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Company	Estimated annual p'chases of raw material (kg)	Product sold wholesale domestic market	Other domestic sales	Export markets	Fish procssng costs	Utilities	Taxes, insurance	Wage costs	Total reported operating costs	Deprec-iation	HACCP development costs	HACCP operating costs (company estimate)	Total costs as reported by company	Total sales (company or research estimate)	Profit/loss	Company estimate of cost increase through HACCP	Economic added value (reported profits plus wages)	Number of employees	Produc-tivity (kg/employee)	Wage costs per employee
1	294000	22%	10%	68%	15850	15996	4284	62311	98441	77889	371115	1675	176330	365160	188830	5%	251141	13	22615	4793
2	126000	5%	0%	95%	13760	5712	3894	46733	70100	158374	88209	9710	122026	155778	33752	10%	80485	12	10500	3894
3	185000	0%	10%	90%	2376575	80580	2220	135168	2594543	155457	288065	17608	na	3500000	na	na	na	32	5781	4224
4	360000	5%	0%	95%	24900	36154	5768	45000	111822	112023	157650	14430	300000	447135	147135	25%	192135	13	27692	3462
5	4454471	10%	15%	75%	145307	380711	52692	696600	na	569397	1363253	0	na	na	na	40%	na	200	22272	3483
6	333333	25%	15%	60%	77500	.25000	8000	90000	200500	98000	124800	6400	1500000	1700000	200000	10%	290000	20	16667	4500
7	605215	22%	0%	78%	9570	59453	15046	101001	185070	137277	83680	7756	2974183	2518244	-455939	5%	-354938	33	18340	3061
8	366667	7%	20%	73%	17910	29400	0	45968	93278	26240	81275	16150	100000	56050	-43950	5%	2018	14	26190	3283
9	210600	25%	5%	70%	87472	16685	26673	276766	407596	121170	748554	35100	4791948	5441810	649862	28%	926628	32	6581	8649
10	489163	9%	0%	91%	122422	53785	24865	153252	354324	170715	279043	22235	1200021	2573259	1373238	10%	1526490	44	11117	3483
11	982000	89%	11%	0%	16026	24525	na	119430	159981	90871	103683	40305	693212	778890	85678	16%	205108	18	54556	6635
12	10000000	0%	3%	97%	731696	25146	3894	46733	807470	586546	989386	7200	8000000	10000000	2000000	10%	na	80	125000	584
***Tota**	**3766978**									**992558**	**2038010**				**2178605**		**3119067**			

Summary table: only companies reporting frozen fish exports

EAV/kg purchased	0.83
Profit/kg purchased	0.58
Average value of fish ($/kg)	1.242041
Average EU price 1999 ($/kg)	1.85
Avge regional price 99 ($/kg)	1.17

Notes

*Total: only companies reporting frozen fish exports

Company 5 and Company 10, wage costs assumed to be $3483 per employee, the average of similar companies (1,4,7,8)

Company 9 is a shellfish specialist, hence the lower reported productivity

1 RO = 2.60 USD

Appendix IX

Selected Country Experience of Impact of Council Directive 91/493/EEC and Commission Inspections

Country, Report and Date	Competent Authority	Summary of Comments of Commission Team	Summary of Official Recommendations
Bahamas XXIV/1081/99 - MR Final	Department of Fisheries under the Ministry of Agriculture and Fisheries.	HACCP not well embedded. Establishments generally defective, especially with respect to water quality, pest and vermin control and general conditions of maintenance and production. Laboratory weaknesses evident.	Training in all aspects of food hygiene required. HACCP implementation and physical improvements in establishments. Laboratory upgrading needed.
Belize DG (SANCO)/ 1038/2000 - MR Final	Belize Agriculture Health Authority (BAHA) for onshore establishments International Merchant Marine Register of Belize (IMMARBE) for fishing vessels.	HACCP in place in establishments for the purposes of export to US. Criticism of the use of water chlorination to eliminate hazards. Weaknesses in the laboratory monitoring system. No residue control system. Deficient establishments. No own checks on products or water. Fishing vessels outside the scope of BAHA regulation. Legislative framework inadequate. Establishments deficient in respect of hygiene.	HACCP plan revisions for establishments necessary. Residue control programme needs to be established. Establishment inspection routine required. Adoption of model health certificate required. One CA needed for onshore plants as well as vessels. Serious legislative gaps need to be filled. Fishing vessel registration issue needs controlling. Water analysis required.
Bulgaria DG(SANCO) 1126/1999 – MR Final Bulgaria DG(SANCO) 1037/2000 – MR Final (Mission on residues) Bulgaria DG(SANCO) 3335/2001 – MR Final	National Veterinary Service	Veterinary supervision and certification Programme and implementation unsatisfactory. Supervision of the distribution of veterinary medicines and laboratory analyses unsatisfactory. Over the review period there have been improvements in the	Comprehensive legislative alignment required. Improvement in laboratories to bring them to international standards needed. Improvement in export certification system Training of inspectors required. Subject to guarantees to the Commission, List 1

		residue monitoring system. Improvement in official monitoring. Improvement in establishments. Still legislative discrepancies. Insufficient training in methods of microbiological analysis of foodstuffs and in implementing a laboratory quality control system. Use of BSS standards, not equivalent to internationally accepted (ISO) standards. Still some residue monitoring problems. Fish farm sampling procedures inadequate. For fishing vessels inadequate use of ice. Transport not clean. Shortcomings in export health certification system. HACCP plans not implemented.	status to continue.
Cameroon DG SANCO 1042/2000 – MR final (follows mission 30 June 1998 placing Cameroon on list 2)	The Bureau de Contrôle de la Qualité des Produits Halieutiques (BCQH) under the Ministère de l'Elevage, des Pêches et des Industries Animales (MINEPIA)	Existence of legislation equivalent to 91/493/EEC and 92//48/EEC. New laboratory expected soon. Sanitary control system satisfactory, although scope for documentary improvements Certification system adequate. No water quality legislation Laboratory facilities adequate, but no lab quality assurance system and no interlab comparative calibration system. HACCP deficiencies: hazard identification weaknesses: neither critical limits nor corrective actions well defined.	Improve health certificate system. Strengthen BCQH. Water quality legislation needed. Reference laboratory required for comparisons. Improve the identified deficiencies in establishments. Improve the official supervision and control system. Subject to guarantees place Cameroon on List 1.

Cape Verde DG(SANCO) 1242/1999 – MR Final	Direccao Geral das Pescas, under the Ministerio do Turismo, Transportes e Mar	For the one approved exporting establishment, no records of own checks available. Health export certification irregularities. No detailed rules for microbiological and chemical analysis for fishery products or water. Laboratory deficiencies.	Legislative revisions needed Laboratory improvements required Lines of authority require clarification Training of officials required Approval procedure required Controls on drinking water required HACCP system in establishments needed Withdrawal from List 2, and new mission required at a later date.
China XXIV 1072/99 MR Final	The State Administration for Entry/Exit Inspection and Quarantine (SAIQ) for fishery products. Ministry of Agriculture is responsible for shellfish.	SAIQ a reliable competent authority. HACCP widespread, started in fish establishments in 1997, generally implemented to a satisfactory standard. Physical structure of plants generally satisfactory. Laboratories generally satisfactory. Remaining weaknesses on shellfish, such as lack of satisfactory monitoring, poor laboratory practices, and an absence of an accreditation system.	Further HACCP training required. Guarantees required, then List 1 for fishery products.
Costa Rica XXIV 1359/98 Costa Rica DG(SANCO) 1050/2000	Direccion de Salud Animal (DSA) under the Ministerio de Agricultura y Ganaderia (MAG)	1998:Uncertainty about independence of inspectors, paid by businesses but accredited by the DSA Use of chlorinated water for cleaning shrimps Water quality control weak Numerous technical weaknesses in factory systems. 2000: Legal provisions equivalent to 91/493/EEC drafted but not yet published in respect of some potential contaminants, otherwise legislation sound after 2000. Laboratory and residue	1998: Improved legislation. Independence of official supervision. Residue monitoring. No employment of chlorinated water. The country remained on List 2, but then took action to rectify shortcomings. 2000: Increase number of inspectors and inspections. Legislation re contaminants needs to be published in Costa Rica Official Journal Potable water legislation needs to be in compliance with relevant Directives.

		monitoring satisfactory. HACCP system applied: critical control points monitored and records kept. Verification by the CA satisfactory. Some monitoring procedures unsatisfactory. Insufficient number of DSA staff Water legislation not fully in compliance Fishing vessels not under the supervision of the CA	Fishing vessel control needed. Costa Rica on List 1 subject to the provision of guarantees.
Falklands 3-7 March 1998 (described as "routine mission")	Veterinary Service of Department of Agriculture	At the time of the report no legislation corresponds to 91/493/EEC and 92/48/EEC, but was expected. Squid traceability and labelling problems. Unacceptable laboratory. Unhygienic procedures on board and during transhipment.	Guarantees that legislative and practical deficiencies will be corrected. Increase in qualified staff required. List 1.
Gabon DG SANCO 1043/2000 – MR Final	Direction Générale des Pêches et de l'Aquaculture (DGPA)	Water quality checks undertaken Sanitary inspection service not operational. No fish quality checks. Irregular visits to freezer vessels. Certification anomalies – confusion between sanitary certification and vessel licensing.	Operationalise sanitary inspection service. Dissemination of legal requirements to interested parties. Begin laboratory analyses. Improved inspection and certification procedures for vessels required. Routine inspection of production facilities. Not to be included on List 1 until recommendations implemented.
Grenada DG(SANCO) 1041/2000 MR final	Public Health Department under the Ministry of Health and Environment – in practice joint supervision by Fisheries Department	No legislative provision for visual checks of fish. Water Act not equivalent to EC legislation. Water quality checks in processing establishments rare. No residue control system. Certification weaknesses.	One CA. Legislation upgrade. Laboratory upgrade. Supervision, export certification and establishment approval systems need improvement. Withdraw from List II and then second evaluation mission recommended.

		Unreliable supervision and establishment approval system. HACCP not implemented although manuals exist.	
Honduras DG(SANCO) 1109/2000 MR Final Followed earlier report (XXIV)/1377/98 MR Final recommending publication of legislation, independence of inspectorate, residue plan, HACCP in approved establishments.	Servicio Nacional de Sanidad Agropecuaria (SENASA) under the Secretary of Agriculture	Independent inspectors. Routine supervision of farms, vessels, establishments. Residue monitoring, but only farms, not establishments. HACCP plans, but based on FDA standards. Weaknesses in certification and approval (for shrimp farms) arrangements. Statistical inconsistencies on export data.	Legislation to be made equivalent to EC Directives. Increase in qualified staff required. Inspection, approval and certification improvements required. Improvement in residue monitoring needed. Laboratory improvements needed. Upgrading Veterinary control of shrimp farms recommended. Correct use of chlorine recommended. Written guarantees to be provided. Honduras on List 1.
India XXIV/1079/99 – MR Final	Export Inspection Council	Legislation meets Directives 91/493/EEC and 80/778/EEC Substantial progress in all areas of hygiene, including HACCP plans in establishments.	Temperature control of peeling areas required. Improvement in block ice production conditions recommended. Upgrading fishing vessels needed. Rectification of observed deficiencies in establishments. Recommendation that India should be retained on List 1.
Iran DG(SANCO) 1125/1999 – MR final	Iran Veterinary Organisation	Legal obligation on establishments and vessels to implement HACCP. Water Directive (80/778/EEC) included in legislation. Laboratories aim to meet EN 45001 standards but some minor deficiencies. Certification system. HACCP correctly implemented. No residue control system. Minor deficiencies in establishments and control system.	Laboratory improvements, establishment inspection frequency and quality, certification improvements recommended. Adaptation of HACCP to individual establishments rather than standard system recommended. Guarantees to the Commission to be supplied and retention of Iran on List 1.

Jamaica XXIV/1085/99 – MR final Jamaica DG(SANCO) 1166/2000 MR final	Veterinary Services Division, Ministry of Agriculture.	1999: HACCP not adequately implemented or monitored. Toxicity monitoring inadequate. Water control concerns. By 2000 HACCP much improved. Improvement in certification and approval systems. Definition of gastropod production areas. Water monitoring inadequacies.	1999: Full implementation of HACCP required. Observed rectification of deficiencies in establishments recommended. Reporting Classification of production areas for marine gastropods to be improved. Monitoring. 2000: Improved analysis of seawater and conch flesh recommended. Other analytical improvements recommended. Routine inspection to take place. Subject to written guarantees Jamaica to be on List 1.
Kenya XXIV/1525/98-MR Final (recommended DG (SANCO) 1127/1999 – MR final (Lake Victoria Pesticide Residues)	Kenyan Ministry of Health, now reported to be the Ministry of Agriculture and Rural Development (see Chapter 3).	1998: view of mission was that there were rectifiable problems of inspection procedures, HACCP, training, traceability, laboratories, landing site hygiene, medical certification. 1999: Pesticide residues resulting in Decision 1999/253/EC – ban. Inadequate monitoring system. Inadequate HACCP.	Kenya to be included on List 1 subject to guarantees in respect of inspection procedures, HACCP, training, traceability, laboratory improvements, landing site hygiene, medical certification procedures. Improvement to monitoring and analytical procedures. Ban remained. Kenya now on List 2.
Morocco DG(SANCO) 3327/2001 – RM Final. Earlier missions referred to in Chapter 3	Direction de l'Elevage, under the Ministère de l'Agriculture, du Développement Rural et des Eaux et Forêts	After earlier inspection missions showing that HACCP was not sufficiently embedded and observing a shortcoming in water quality monitoring, significant improvements. Well-trained inspection teams. Application of HACCP. Laboratories well equipped, but uneven in standards. Absence of a laboratory in the south of the country. Bivalve monitoring	Bivalve management system – classification of production zones and surveillance system. Monitoring coastal vessels. Improvements to laboratories. Inclusion on List 1 subject to guarantees.

		weakness. Landing site weaknesses. HACCP implementation insufficient in establishments. Water monitoring still below standard.	
Namibia DG(SANCO) 1092/1999	Ministry of Trade and Industry, (with the South African Bureau of Standards (SABS) as the technical body at the time of the report).	An earlier mission had made several recommendations, including HACCP training No major deficiencies. Continued monitoring by SABS regarded as valuable.	The Namibian authorities to notify the Commission if the services of the SABS is terminated. Some laboratory technical improvements required.
New Caledonia DG(SANCO) 1270/2000-MR final	Direction de l'Economie Rurale (DER)	No major deficiencies.	Minor improvements to laboratory practices recommended.
Nicaragua DG(SANCO) 1110/2000	Direccion General de Proteccion y Sanidad Agropecuaria (DGPSA), under the Ministerio Agropecuario y Forestal	Satisfactory HACCP systems generally in place. Certain weaknesses on 91/493/EEC. Water analysis not carried out. Other laboratory weaknesses. No fishing vessel control	Fishing vessel sanitary control needed. Strengthened legislation desirable. Laboratory improvements recommended. Establishment deficiencies to be corrected. List 1.
Pakistan XXIV 1069/99 MR Final	Marine Fisheries Department under Ministry of Food, Agriculture and Livestock	Improvement in establishments since 1997 visit in respect of structure, maintenance, hygienic conditions. HACCP in shrimp processing plants. Auction area for shrimps was chilled, no birds, adequate toilets. All peeling shed closed. Laboratory and upstream (fishing fleet) weaknesses.	Fishing fleet needs improvement. Hygienic transport for block ice required. Hygienic transport of shrimp recommended. List 1.
Philippines DG(SANCO) 3320/2001 MR final	Bureau of Fisheries and Aquatic Resources (BFAR)	Request from the Philippines to export processed bivalve molluscs, marine gastropods, tunicates and echinoderms to EU. Mission also re-examined fish procedures. Equivalent legislation for food. Inspection system extant. A number of laboratories.	The country to provide standards on potable water. BFAR to review list of establishments as most below standard. Hyperchlorinated water should be avoided. Laboratory improvements and the training of inspectors recommended. List 1.

		Water regulations could not be evaluated. Line management problems at BFAR. Unreliable laboratory analyses. Some establishments not in conformity.	
Romania DG(SANCO) 1274/2000 MR Final	Agentia Nationala Sanitaria Veterinaria (NSVA) under the Ministerul Agriculturii si Alimentatiei	Legislation equivalent to EC Directives. HACCP implemented in establishments. HACCP considered to be GMP, but the result is that CCPs are insufficiently monitored. No analyses take place in establishments.	Sanitary control of fishing vessels required. Monitoring of contaminants to be implemented. Improvements in HACCP in establishments needed. List 2 currently.
Senegal DG(SANCO) 1123/1999 - MR Final	Ministère del a pêche et des transports maritimes – Direction de l'océanographie et des pêches maritimes (DOPM), Bureau du contrôle et des produits halieutiques (BCPH).	Legislation equivalent to EC, except water and histamine and mercury tolerances. Surveillance plan for contamination of fisheries products. Laboratories satisfactory. Alerts: salmonella, Vibrio cholerae, Vibrio parahaemolyticus, histamine. Documentation management substandard. Intercalibration not practised. Problems: hygiene on board vessels, excessive use of chlorine, imperfect application of HACCP, product and water sampling procedures inadequate.	Water, mercury and histamine legislation essential. Intercalibration and harmonisation between national laboratories must be implemented. List of establishments should not include entities outside EC criteria. Improvement and formalisation of official controls on production. List 1.
Seychelles DG(SANCO)3330/2001 – MR final	Fish Inspection and Quality Control Unit (FIQCU)	Since 1998 the Seychelles has increased inspection staff, improved documentation, increased HACCP training, improved monitoring. Legislation equivalent. Organoleptic sampling programme. Chemical checks: mercury and histamine. Microbiological checks. Some factory vessels below standard, no own	Legislative improvement by including factory and freezer vessels. Monitor mercury better. Abolish health certificate for non-Seychelles vessels. De-approval some factory vessels. List 1.

		checks: practical application HACCP to factory vessels defective.	
Sri Lanka DG(SANCO) 1291/2000 – MR final	Department of Fisheries and Aquatic Resources (DFAR), under Ministry of Fisheries and Aquatic Resources (MFARD)	HACCP plans, but identification of critical points deficient. Following documentary evaluation of dossier, Sri Lanka on List 2 from 1999. Absence of adequate control of potable water.	Additives legislation required. Residues legislation and monitoring programme for aquaculture. Legal bases for enabling CA to approve laboratories required. Record keeping improvements needed. HACCP improvements throughout the chain. Sri Lanka on List 2.
Tanzania DG(SANCO) 1276/2000 MR final	Fisheries Division, Ministry of Natural Resources and Tourism	Follows report DG(SANCO) 1128/1999 – MR Final on pesticide residues after a ban. HACCP system follows steps correctly. Licensing system for collection and fishing vessels extant. Laboratory weaknesses: no quality assurance. Residue monitoring deficiencies. 1 establishment deficient: poor internal own checks. Fish traceability weaknesses.	Training in HACCP audits for inspectors required. Supervision of inspectorate needs to be improved. Some laboratory improvements – physical and analysis - required. Stronger supervision of establishments' own checks systems needed. Written guarantees required, and inclusion on List 1.
Uganda, XXIV/1524/98 – MR final Uganda, DGSANCO/ 1129/1999 – MR final Uganda DG(SANCO) 1277/2000 – MR final	Initially Uganda National Bureau of Standards, with inspection and export certificate issue delegated to the Fisheries Department. Now Department of Fisheries Resources.	Initially Uganda failed on most counts. The official procedures, such as monitoring, were inadequate, there were weaknesses in corrective actions and documentation was poor. Some of the processing plants had various deficiencies, including inadequate HACCP plans. Much has changed as a result of a change in the CA, the training of staff, the preparation of a procedures manual, laboratory improvements, traceability. Some plants still have inadequate drainage and	Laboratory improvements, including staff training required. Improvements in verification procedures of factories needed. Still some factory improvements needed. Manual of Operating Procedures for Fish Inspection needs to include Vibrio Cholera test. Improvements in pesticide monitoring required. List 1 subject to assurances

		vermin control.	
Vietnam DG(SANCO)/ XXIV/1464/98 – MR final (concerns mainly 91/492/EEC) Vietnam DG(SANCO)/ 1130/1999 – MR final (concerns almost entirely 91/492/EEC)	National Fisheries Inspection and Quality Assurance Centre (NAFIQACEN) under the Ministry of Fisheries, with co-responsibility delegated to the Fisheries Resources Protection Department	1998: Increase in the number of employees of NAFIQACEN following a 1997 report. Awareness of hygiene requirements Report refers to earlier report (1997) stating that the requirements of 91/492/EEC, particular as regards surveillance of the mollusc production areas. Laboratory weaknesses, especially with respect to microbiological analysis. Weaknesses in monitoring procedures Establishments in general below standard in respect of hygiene, for example, excessive manual manipulation of product, and HACCP not correctly applied. 1999: Laboratory facilities deemed adequate. Establishment inspection and certification procedures deemed adequate. Some shellfish processing establishments presented structural weaknesses. Some HACCP plans do not cover all the steps in the manufacturing process.	1998: Laboratory improvements needed. Shortened list of approved establishments required. Monitoring of bivalve molluscs required, including appropriate laboratory facilities. 1999: Certification improvement required Faster analysis for phytoplankton and marine biotoxins needed. "Own checks" improvements needed. Structural and operational corrections required at some plants. Approval for List 1 with respect to fishery products.
Yemen XXIV/1519/98 – MR Final	Technical Department of Quality Control of the Ministry of Fish Wealth	Many processing establishments have numerous physical defects, such as contaminated ice, inadequate changing rooms, unhygienic lavatories. Own checks (HACCP) systems deemed inadequate.	HACCP training required. New qc laboratory needed. Monitoring requirements. New list of establishments to be drawn up. Subject to this List 1.

Source: Europa Website (http://forum.europa.eu.int/irc/sanco/vets/info/data/listes/ffp.html)

Appendix X

Correspondence Between Council Directive 91/493/EEC and the Thesis, and the Questionnaire

Key Obligations Arising from the Directive Directive 91/493/EEC	Commentary
The Directive lays down the health conditions for the production and the placing on the market of fishery products for human consumption	The thesis studies the application of one element of the Directive (Article 6) to Oman. HACCP is not specified by name in 91/493/EEC although Article 6 comes close to defining the requirement. As a management tool it has grown in significance and has come to be seen as a necessary constituent of industry practices if the health conditions are to be met. This is evident from the series of Commission reports into health conditions, summarised in Appendix IX. The basic objective of the questionnaire was to test the implementation of HACCP system in a sample of Oman's fishery product processing establishment.
Article 2, definitions	The sample included Omani plants processing "fishery products" in general (Article 2.1), "processed" fishery products (Article 2.5) and "frozen" fishery products (Article 2.8). Fishery products exported from Oman to the EU fall into the definition "importation" meaning "the introduction into the territory of the Community of fishery products from third countries" (Article 2.16). The questionnaire was an assessment of HACCP implementation and was restricted to fishery product processing plants. The questionnaire was necessarily restricted so understanding of basic definitions was not included.
Article 3, conditions for placing on the market of fishery products.	The rules for the detailed application of this Article are included in an Annex to the Directive, discussed below.
Article 4, concerns live products	The marketing of live fishery products is rare in Oman. Consideration of the issue is not included in this thesis.
Article 5 forbids placing on the market poisonous fish and ciguatoxic fish.	The poisonous fish referred to in the Article (Tetraodontidae, Molidae, Diodontidae, and Canthisgasteridae) are not normally landed in Oman. Ciguatera is not normally associated with fish landings in Oman.
Article 6 imposes an obligation on Member States to ensure that establishments meet the specifications of the Directive.	This Article requires a system of own checks based on the identification of critical points, systems for monitoring the critical points, sampling processes and recording systems. Failure to have such systems in place is an important reason for bans on fish imported into the EU. The questionnaire is designed to assess if the "own checks" requirement of this Article is being met. The "own checks" system referred to in this Article evolved into HACCP systems. This evolution was formalised in Commission Decision 94/356/EC (OJ L 156/50 of 25.9.94).
Article 7 is concerned with the definitions and responsibilities of competent authorities within Member States.	This is only relevant to Oman inasmuch as an equivalent system of regulation is required. The recognised Competent Authority in Oman is Ministry of Agriculture and Fisheries.

Article 8 permits on-the-spot checks on establishments to verify compliance with the Directive in Member States.	On the spot checks also take place in third countries. Commission Decision 98/140/EC of 4 February 1998 lays down detailed rules concerning on-the-spot checks carried out by Commission experts in third countries.
Article 9 concerns protective action (if necessary) to be taken in Member States following inspections.	Not relevant to Oman as it is not a Member State.
Article 10 requires that the provisions applied to imports of fishery products from third countries shall be at least equivalent to those governing the production and placing on the market of Community Products.	The questionnaire tests Omani compliance with one aspect of Directive 91/493/EEC. In studying the degree of equivalence in third countries it becomes clear that full compliance has proved difficult for many. Progress has been made, but most have some shortcomings (see Chapters Three, Eight and Appendix IX)
Article 11 outlines the procedures for inspection of third countries.	The questionnaire addresses the question of HACCP implementation in Oman. Experience indicates that the standard of HACCP implementation is a frequent weakness in third countries (see Chapter Eight).
Article 12 concerns inspections made by Member States. Articles 13 to 19 deal with implementation issues, of concern, principally, to Member States.	Not directly relevant to Oman.
ANNEX to Directive 91/493/EEC	Provides significant additional detail to the Directive
Annex Chapter I concerns factory vessels.	This issue is not covered by the thesis.
Annex Chapter II states in detail the requirements during and after landing.	The issues raised in this Annex are of direct relevance to Oman and are dealt with in the body of the dissertation (see Chapters Four and Eight).
1. Unloading and landing equipment	Referred to in Chapters Three, Four, and Eight
2. Procedures for unloading and landing: speed, placing fish in a protected environment, damage as a result of poor equipment and handling practices.	The steps and conditions of fish handling have been investigated and are discussed in Chapters Four and Eight.
3. The conditions of auction and wholesale markets	The researcher observed the types of fish processing, landings and handling of fresh fish, and visited a number of fish markets and auctions to gain an overview of the fisheries sector. The observation of these activities helped the researcher to evaluate each plant, as well as to interpret the questionnaire and interview results (Chapter Four, Section 4.6.5).
4. Transport after first sale	There is no system for the official mandatory and control of the transportation and distribution of quality fish (Chapter Four, Section 4.6.4).
5. Requirement for cold rooms at markets	Potential and actual improvements are discussed in Chapter Four.
6. Application of general hygiene conditions at markets	Economic waste occurs because of poor quality fish, due to poor hygiene in handling fish in the market place. The economic losses due to the lack of ice and insanitary handling are reviewed in Chapters Three and Four.
7. Application of rules to wholesale markets	The thesis includes recommendations for the improvement of hygiene standards in wholesale market (Chapter Four)
III.1 Conditions for establishments on land	

I. General conditions relating to premises and equipment 1. Working area sufficiently large	This issue was not included directly in questionnaire. However, the researcher did obtain evidence of significant investment by processors (see Chapter Eight and Appendix IX), confirmed by observation. The professional experience of the researcher indicates that the facility layout has not in general been considered carefully enough in Oman. To overcome this thesis recommends that prior to the construction of a new plant or modification of an existing one, the regulatory authority (MAF) is recommended to analyse the propose plant projects.
2. Description of establishments: (a) waterproof flooring, (b) walls, smooth, easy to clean, durable impermeable; (c) ceilings and roof linings easy to clean; (d) doors in durable materials which are easy to clean; (e) adequate ventilation and, where necessary, good steam and water vapour extraction facilities; (f) adequate natural or artificial lighting; (g) adequate number of facilities for cleaning and disinfecting hands. In work rooms and lavatories taps must not be hand-operable. Facilities must be provided with single use land towels; (h) facilities for cleaning plant, equipment and utensils.	The thesis notes the need for prerequisite programmes as a necessary foundation for HACCP. These requirements are discussed in Chapters Seven and Eight and specific recommendations to overcome non-compliance with EU requirements are proposed in Chapter Nine.
3. Application of (a) to (f) above to cold rooms.	See Chapters Two, Eight and Nine.
4. Protection against pests.	Question 27 in the questionnaire
5. Instruments, cutting tables and other equipment to be made of corrosion-resistant materials, easy to clean and disinfect. 6. Corrosion-resistant containers for fishery products not intended for human consumption and appropriate storage. 7. Clean drinking water. 8. Hygienic waste disposal. 9. Changing room standards. 10. Lockable inspection room. 11. Facilities for cleaning transport.	Investigated through the checklist used in this study (see Appendix III).
12. Live animal facilities (e.g., live molluscs).	Generally not relevant to Oman

General conditions of hygiene A Applicable to premises and equipment 1. Floors etc. must be kept in a satisfactory state of repair and cleanliness 2. Rodents and other vermin must be exterminated, but care with toxic chemicals required. 3. Working areas only for fishery products.	The approval of establishments for fish export by the Competent Authority is given according to the sanitary levels and cleanliness in such companies and according to their adherence to all sanitary and health rules related to fisheries products. These issues were investigated through the checklist used in this study (see Appendix III)
4. Drinking water or clean sea water only to be used.	The microbial condition of ice or seawater for Refrigerating Sea Water (RSW), especially if they are contaminated with psychotropic spoilage organisms, might be considered a hazard leading to a CCP. Examination by the regulatory authority of used water for coliforms and other pollutants to check compliance would then be considered as necessary.
5. Competent authority must approve detergents and disinfectants.	The Omani Competent Authority should approve detergents by using a procedure whereby the toxicity of the chemicals is evaluated, as well as their possible transfer to the product. It is essential that the cleaned and disinfected surfaces, equipment, and utensils be rinsed with clean water before coming in contact with food products. As to the sanitation process itself, there are no specific Omani rules or guidelines- this is acknowledged to be a weakness in the Omani system. According to Article 6 of the main Directive, the plant must take samples for analysis for the purpose of checking cleaning and disinfection methods. In fishery industry, designated and trained personnel must be assigned to this job. They must be trained in the principles of general food hygiene and sanitation and know a plant's specific problems. This study reveals that there were few respondents able to identify correctly the best substance to be used for cleaning and disinfecting inside a refrigerator, freezer or cold store, and to identify the substance which is considered to be a good food contact surface sanitizer (Chapter Eight).
B General conditions of staff hygiene 1. (a) clean working clothes (b) hand washing (c) smoking, spitting etc. prohibited. 2. Stop contaminating persons from handing fishery products, medical certificates required.	The rules adopted in Oman for fisheries processing and handling personnel are that any person before working in this field is asked to submit a medical certificate showing that Health Authority has no objection towards the practising of the job in question. This certificate is issued only after necessary medical tests are made. Personnel working in the field of fisheries product handling are sent for the same medical tests once in every year or more. These issues are investigated in Personal Hygiene Principles and Practices Section of the Questionnaire (Questions 38, 39, 40 and 41).
IV Special conditions for handling fishery products on shore	These are discussed in Chapter Four

I. Conditions for fresh products	Fish temperature should be lowered as soon as possible to 0°C after capture and that temperature should be carefully maintained. Capture, handling, and transportation are responsible for a great release of adrenaline and cortisol in fish tissues causing shortening of time for onset of rigor mortis, which softens fish texture and enhances the ease of penetration by pathogens (discussed in Chapters Two and Four).
1. Use of ice for storage. 2. Hygienic heading and gutting. 3. Hygienic filleting and slicing. 4. Removal of guts.	Exposure of fish to sun and air is undesirable. Bleeding, gutting, cleaning, and washing should be carried out thoroughly. The digestive tract, which is often enriched with many microorganisms, has to be removed, and spillage should be minimized in order to restrict flesh contamination. Surface drying can hinder surface microbial growth. Although gutting removes a large reservoir of potential spoilage bacteria, it makes possible for microorganisms to attack the fish flesh. Therefore, proper hygienic conditions are required during the whole procedure, while visual inspection can be carried out as well. Furthermore, automatic machines can be used for evisceration, instead of manual gutting, which is faster than manual processes. In this case, attention should be paid to cleaning and disinfection of the equipment, since any remaining material (blood, flesh, etc.) can be substrate for pathogens. These issues are discussed in Chapters Two and Four.
5. Well-design containers, facility for drainage of melt water. 6. Adequate waste disposal facilities and arrangements.	This requirement is not specified under Omani regulations (Quality Control Regulations No.4/97)
II Conditions for frozen products	
1. (a) Freezers for rapid temperature reduction (b) Appropriately low temperature, not more than –9 degrees C.	Freezing fish requires close contact of ice with fish. Cooling should start immediately after catching in order to keep the fish temperature down to 3°C or below within 1 hour, which might be possible only for small fish .For larger fish, prechilling is advantageous and is achieved with a RSW system at such a rate that temperature gets below 3°C within 4 h, below 0°C after 16 h, and then remains constant from -1.5 to 0°C until unloading. Prompt chilling is crucial to prevent the formation of toxic levels of histamine. Decomposition and histamine formation in tuna are likely to occur when its core temperature is approximately 0°C during marketing and shipping. Compliance with good practice in freezing technology is investigated through questions 36 and 37 of the questionnaire.
2. Fresh products to be frozen must comply with "fresh" requirements.	The only sanitary law concerning fishery products in force in Oman is the Ministerial Decision 4/97, Omani Fishery Export Regulation (which states, inter alia, fisheries products are not allowed to be marketed if the level contaminants in these products exceeds the allowable limits stated in Paragraph (3 b) -EU Decision 91/493/EEC). These standards are now under the process of being updated in accordance with recent recommendations of WHO.
3. Easy to read temperature recording and records available for inspection.	Investigated through question 23 of the questionnaire.
III Conditions for thawing products 1. Hygienic conditions 2. After thawing must be marked as such.	Not relevant to Omai fish processors because product is in general exported frozen.

IV Conditions for processed products 1. Fresh, frozen and thawed products must comply with other requirements of this Chapter. 2. Careful treatment of treated processed products to comply with specific control mechanisms.	Chapter VIII includes a discussion of processing plant conditions. It states that at the processing plant, sorting and washing should be conducted with high quality water, and utensils (e.g., knives and machines) should be thoroughly cleaned prior to use (see Chapter Eight). After filleting the fillets must be refrigerated or iced again. This stage is important because it is the last one prior to consumption of the product (questions 20, 22, and 24).
3. Appropriate labelling of processed products.	Observation suggests that most fish processors are aware of labelling requirements.
4. Canning (a) drinking quality water (b) appropriateness of heat treatment (c) system of checks on heat treatment (d) sampling procedure (e) checks to ensure containers not damaged (f) batch traceability	Although, there are two factories operating in Oman as yet, there are no technical specifications under Omani regulations (Quality Control Regulations No.4/97) setting-up a processing procedures or monitoring for such industry. Neither of the two factories adopts HACCP system in their operations, nor export to the EU.
5. Smoking (a) separation of smoking materials (b) prohibition on use of prior chemically treated wood (c) rapid cooling of product	In general not applicable to Oman.
5. Salting (a) Separation of salting operations (b) clean salt (c) avoid contamination of containers (d) clean salting containers	In general not applicable to Oman.
7. Cooked crustacean and molluscan shellfish products	Generally not applicable to Omani fish processors
8. Mechanically recovered fish flesh	Although there is some equipment of this type in Omani fish factories, the output is not generally used for export, and is not therefore seen as being a CCP.
V Parasites: inspection, removal and treatment	The presence of parasites was not noted as a hazard by any of respondents.
CHAPTER V HEALTH CONTROLS AND MONITORING OF PRODUCTION CONDITIONS	
Checks by CA on: 1. fishing vessels 2. first sale conditions 3. handling conditions 4. wholesale and auction markets 5. storage and transport	Activities of the Competent Authority in Oman are discussed in Chapter Three.
2. Parasite checks	Fishery products before being sent to market or before being processed in the plant are subjected to visual tests to detect the presence of parasites, by taking samples as per the sampling plan (Article 10 & 11 of Quality Control Regulations No.4/97). Any infected fish is be disposed of.

3. Chemical checks: TVB-N, TMA-N, histamine, contaminants in aquatic environment	The analytical methods related to laboratory examinations are done according to Omani Standards Specifications No.778/95 (Methods for physical and Chemical Analysis of fish, shellfish and their products), and the Omani Standard No. 627/96 (Methods of Microbiological examinations for meat, fish, shell-fish and their products). Concerning the tolerance level of mercury, the provisions of Article 20-6 of Quality Control Regulations for Omani Fishery Exports No. 4/97 are adopted. With regard to the monitoring programme, the Omani Standards specifications No.104/84 and Gulf Standards 20/84 concerning heavy metals tests are adopted (Annex 3). Organoleptic checks for all batches of fishery products are undertaken to verify that they are fit for human consumption. Microbiological criteria for all fisheries products including cooked crustacean and moluscan shellfish are under preparation in accordance with Commission Decision 93/51/EEC.
CHAPTER VI PACKAGING Hygienic conditions specified	The quality control act for seafood exports issued first in1997 (QCA-97) aims at enhancing Oman fisheries exports through the assurance of high quality fish products. This covers hygienic regulations for plants and their personnel, including buildings, equipment, transporting, labelling, and packaging (Chapter Three).
CHAPTER VII IDENTIFICATION MARKS	
Traceability to country of origin, approval number, registration number of wholesale market	The Competent Authority in Oman requires these provisions to be met.
CHAPTER VIII STORAGE AND TRANSPORT Hygienic conditions specified	

Correspondence Between the Questionnaire and the Description of HACCP in Commission Decision 94/356/EC

Key Obligations Arising from Commission Decision 94/356/EC laying down detailed rules for the application of Council Directive 91/493/EEC	The Questionnaire
Article 1 defines "own checks" in Article 6(1) of Directive 91/493/EEC as "all those actions aimed at ensuring and demonstrating that a fishery product satisfies the requirements of the Directive." The Article also permits the use of GMP guides and requires appropriate training for staff.	Although the acronym "HACCP" was not used in Decision 94/356/EC, the Commission acknowledges that this is the point when it was directly included amongst the legal obligations upon fishery product processing establishments. As a management tool it has grown in significance and has come to be seen as a necessary constituent of industry practices if the health conditions are to be met. The study employs a questionnaire to test the implementation of HACCP in Omani fish processing factories. The questionnaire is reproduced at Appendix I and the research methodology is discussed in Chapter Six. The study aims to explore the process of HACCP implementation, to obtain information on the industry's hazard awareness and to establish the barriers to HACCP implementation in the Omani food sector, using the seafood processing sector as a case study.
Article 2 defines a "critical point" as "any point, step or procedure at which control can be applied and a food safety hazard can be prevented, eliminated or reduced to acceptable levels."	Identification of CCPs is a crucial step in developing and maintaining the HACCP system. It requires technical expertise and a quantitative approach. In Oman-fish processing industries have difficulty obtaining the scientific information necessary for developing sound hazard assessments, or for identifying specific support needed to implement HACCP. Lack of technical references and epidemiological data result in inability to distinguish between the relative risks of different pathogens for particular foods. This issue is investigated in questions 19, 52 and 53 of the questionnaire.
Article 3 defines "monitoring and checking" of critical points as including "all those set observations and/or measurements necessary to ensure that critical points are kept under control". It specifically excludes the verification that end products conform with the 91/493/EEC standards.	Questions 22 and 24 which were put to the respondents, aimed to investigate the extent of compliance with HACCP implementation in terms of monitoring the temperature of food products at different stages or steps in processing.
Article 4 confirms that samples for analysis should go to a laboratory approved by the competent authority, a transparent evidence-based system of checks should be established, and that the "own checks" system should be confirmed.	Samples of ingredients, materials obtained from selected points during the processing or handling, and final product are investigated in question 20. Such sampling and testing. For export of tuna, for example the EU recommends that to test for histamine one every three consignments exported to the EU.
Article 5 concerns the approval of laboratories. The CA-approved laboratories have to be of international standard, but establishments' laboratories are not so constrained.	It seems to have been a matter of significant concern for the Commission inspectors of exporting countries that many laboratories were below standard. Laboratories are officially approved if they are equipped with the required chemical, equipment, and the competent staff. The following laboratories are officially approved by EU in the Sultanate:

	• Laboratories of Ministry of Health. • The Central Laboratory of the Ministry of Commerce and Industry. • The Quality Control Laboratory of the Ministry of Agriculture and Fisheries.
Article 6 defines the information which the establishment must retain: (a) product descriptions (b) description of manufacturing process (c) identification of critical points (d) a description of hazards, risks, control measures for each critical point (e) a description of monitoring and checking procedures (f) a description of procedures for verification and review (g) a record of observations and measurements (h) a record of corrective actions undertaken (i) an easy document retrieval system for each batch to permit traceability.	The HACCP plans of selected companies were evaluated and critically examined. To understand, explain and predict the operators' daily activities in their plants, the researcher checked their activities while they were receiving, handling, processing and storing the fish. The researcher's aim here was to obtain an insight into aspects of the demands of the on HACCP system and the level of sanitation of their facilities as it existed and which was practised in the day-to-day processing in each plant. A number of questions were used (19, 20, 21, 22, 24, 27, 28, 29, 31, 32, 34, 38, and 40) to assess the respondents' knowledge about food storage, cross contamination and temperature control procedures. In particular, these questions were designed to assess the respondents' knowledge of preventive measures against food poisoning, common causes of food contamination, safety systems for storage and handling of food, and the practical application of temperature control in food processing and storage
Article 7 requires the CA to ensure appropriate training of inspection staff to allow them to assess own checks.	The food inspectors in Oman are not adequately trained and lack professionalism and a good understanding of food safety service (Chapter Four). The Questionnaire investigated level of food safety and hygiene training, and in the HACCP system (questions 6-9). The present study reveals that only a small number of food handlers have been trained to carry out tasks in way which minimise the likelihood of contamination. This study also, showed that fish establishments had little incentive to train employees.
Article 8 requires Member States to communicate difficulties with application of this Decision to the Commission.	Not applicable to Oman
ANNEX General Principles: identification of hazards, analysis of risks and determination of measures necessary to control them identification of critical points identification of critical limits for each critical point establishment of checking procedures establishment of corrective action to be taken when necessary establishment of verification and review procedures establishment of documentation concerning all procedures and records.	Based on the study, the most problems and difficulties associated with well-designed and applying the HACCP system in the Omani fish industry sector at the time of the survey of companies can be summarised as follows: Conducting a hazard analysis: As noted from this study, both identification and evaluation of hazards requires knowledge of which microorganisms are potentially of significance in the food being produced. In the process of identifying hazards, the crucial issue is access to relevant background information on what the real hazards are for a particular product and process. In Oman, food processing industries have difficulty obtaining the scientific information necessary for developing sound hazard assessments, or for identifying specific support needed to implement HACCP. The researcher observed that there was a general lack of knowledge of food poisoning and foodborne infections. No previous studies have investigated these aspects among the fish or food processing industry in Oman. Thus, the current study contributes significantly in addressing the apparent lack of information and awareness of pathogens in the fish processing industry. Determining CCPs:. Lack of consistency and clarity in describing the

	procedure to determine CCPs that were needed to assure production of safe foods was one of the notable deficiencies in the Omani HACCP plans. Some firms did not provide any supporting documentation including the rationale for selecting CCPs or validation studies establishing that the control measure(s) and critical limits(s) were effective. These highlighted that there is not always a clear understanding or agreement on what constitutes a HACCP plan. The identification of CCPs, as a part of the HACCP system, requires technical expertise and a wide knowledge in the product and processing. CCP determination relies on proper hazard analysis. Therefore, failing to justify hazards means failure in determining CCP. Establishing critical limits: Obtaining information to determine the appropriate critical limits can prove to be difficult in Oman as this is largely a scientific process that requires reference to known and scientifically determined values. Monitoring procedures: Monitoring needs to be accurate and provides a true indication of the results. Inaccurate and false results are often recorded by employees due to the mistaken belief that they will be punished if the results are not what they should be and that the company wants to see records that indicate control of process. Experience from this study indicates that the presentation of comprehensive records of temperature monitoring do not always mean that temperature is being monitored in practice. This may be particularly true in situations where staff assigned to the task of monitoring and recording temperature lack sufficient understanding of the rationale for such an exercise. Establish corrective actions: There is frequently a need to take corrective action. Authority for these decisions is often the responsibility of senior management. This is not always appropriate, as a senior manager may not have the technical expertise to make these decisions and may not always be available to make urgent decisions. The HACCP team should carefully consider who has the appropriate skills and knowledge to determine corrective actions. Verification: There is a shortage of effective and experienced auditing teams. Once a HACCP plan has been developed and introduced into a food operation, it should be maintained on a continuous basis and auditing is a commonly used tool to ensure this. Verification of the HACCP plan and implementation is one of the problems that hinder the successes of the system, where few people are trained in this field. Documentation and record keeping: There was lack of knowledge on what type of information should be included in records and the importance of reviewing and signing records. The records should indicate when control of a CCP is being lost, as that allows the manufacturer to take corrective action to remedy the problem.