THE STATUS OF FISH IN MALAYSIAN DIETS AND POTENTIAL BARRIERS TO INCREASING CONSUMPTION OF FARMED SPECIES

Ee Von Goh

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ABSTRACT

The thesis took an interdisciplinary, problem-oriented approach to address the research problem: 'Is farmed fish capable of replacing wild-caught fish in the Malaysian diet?' The main objectives of the project were to assess current fish consumption habits, evaluate the impacts of these on sustainability of fish stocks and determine whether aquacultured products could be a suitable substitution. A combination of data collection methods was used, namely dietary assessments, systematic literature review, market research interviews and surveys and analysis of electronic and paper-based official records. The review of the Malaysian food balance sheets showed a significant transition in diet over the last three decades, specifically with respect to an increase in animal protein by approximately 60% over this time, with fish as the major source of protein. To further explore the contribution of fish to the diet of Malaysians, and any ethnic and geographical differences in consumption, a food frequency questionnaire (FFQ) was developed to assess habitual dietary intakes within selected coastal, rural and urban populations across different cultural groups in Klang Valley. The FFQ provided a clearer picture of the quantities of fish consumed by Malaysians and enabled the characterisation of Malaysian fish consumers based on the types of fish species consumed for sustainability assessment purpose. The nutritional contribution of wild versus farmed fish was compared and contrasted. Results from this study, combined with detailed studies of perception of wild versus farmed fish by consumers, aquaculturists and wholesalers, provided a greater understanding of the factors that influence consumers' fish buying and consumption habits. The key findings are discussed with respect to the sustainability of the current situation, potential for expanding the aquaculture sector to replace wild fish in the Malaysian diet and recommendations for future research and issues for policy makers involved in the expansion of the industry.

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List of Abbreviations

24HR	24-Hour Recall
AHA	American Heart Association
ALA	alpha-Linolenic acid
AMCS	Australian Marine Conservation Society
ASEAN	Association of Southeast Asian Nations
BDA	British Dietetic Association
BMI	Body Mass Index
BMR	Basal Metabolic Rate
CAP	Consumers Association of Penang
CFFRC	Crops for The Future Research Centre
CHD	Coronary Heart Disease
CPG	Clinical Practice Guidelines
CVD	Cardiovascular Disease
DHA	Docosahexaenoic acid
DLW	Doubly Labeled Water
DoFM	Department of Fisheries Malaysia
DoSM	Department of Statistics Malaysia
DPA	Docosapentaenoic acid
EE	Energy Expenditure
EFA	Essential Fatty Acid
EI	Energy Intake
EPA	Eicosapentaenoic acid
EPU	Economy Planning Unit
FAO	Food and Agriculture Organization
FBS	Food Balance Sheet
FDAM	Fisheries Development Authority of Malaysia
FFQ	Food Frequency Questionnaire
GDP	Gross domestic product
HBS	Household Budget Survey
HDL	High Density Lipoprotein
HUFA	Highly unsaturated fatty acids
ICD	International Classification of Diseases
IDS	Individual dietary survey
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported and unregulated
LDL	Low Density Lipoprotein
MANS	Malaysia Adult Nutrition Survey
MSC	Marine Stewardship Council
MUFA	Monounsaturated Fatty Acid
NCD	Non-Communicable Disease
NCFFN	National Coordinating Committee on Food and Nutrition

NEP	New Economic Policy
NGO	Non-governmental organizations
NHMS	National Health & Morbidity Survey
PUFA	Polyunsaturated fatty acids
RNI	Recommended Nutrient Intakes
SD	Standard Deviation
SDG	Sustainable Development Goal
SEAFDEC	Southeast Asian Fisheries Development Center
SFA	Saturated Fatty Acid
SPSS	Statistical Package for the Social Sciences
TEE	Total Energy Expenditure
WHO	World Health Organization
WWF	World Wildlife Fund

CHAPTER 1: INTRODUCTION

The thesis explores the role of fish in the diet, using Malaysia as the research centre. Briefly, by way of introduction, the FAO and DoF estimated per caput supply put Malaysians among the world's top fish consumers: the FAO estimated 52.1 kg per caput supply of fish for direct human consumption in 2005 while the Malaysian DoF reported that the fish supply per capita was 46 kg in 2010 and will increase to 55 kg by 2020. The average increment of fish consumption in Malaysia is constant at about 1.6% yearly since the year 2000 (Abu Bakar et al., 2013) but actual annual fishery landings in Malaysia do not observe a similar growth trend (DoFM, 2000-2012). Marine fish production is considered fully exploited as a result of unsustainable fishing practices and environmental impacts. To cater for continuously high demand, Malaysia needed to import these fishes from countries like Thailand and Indonesia. Consequently, the amount of import bill grew tremendously, putting Malaysia as a net importer of seafood since 2008 until today. However, the fish consumption pattern of Malaysian is not well studied. Aquaculture activities have started to be promoted in order to help achieve fish supply and demand equilibrium. Consumer-held perceptions of farmed fish have received garnering attention in the western countries recently (Verbeke et al. 2005; Verbeke and Vackier 2005; Verbeke et al. 2007; Vanhonacker et al. 2011; Hall and Amberg, 2013; Schlag and Ystgaard, 2013; Claret et al 2014) but are still poorly understood in Malaysia. Before considering this specific topic further and in depth, a broad overview of the subject area is provided in Chapter 1.

1.1 THE CONCEPT OF A SUSTAINABLE DIET FOR HUMAN HEALTH

Historically, the study of diet can be traced as far back as the writings of Homer, Plato, and Hippocrates in ancient Greece (Hwalla and Koleilat, 2004). Diet and nutrition have always been judged important for health. Nutritional research was focused on the study of specific nutrients, or specific foods or food groups, and their impact on human health (Carpenter, 2003 a-d). In recent years, increasing attention has been given to answering the questions of diets and their impact on the environment and food systems. This has led to the recognition of the significance of the environmental component of a healthy diet by FAO. In 2010, the FAO recognised that the health of human beings is closely linked to the health of ecosystems, leading to the development of a consensus definition for “sustainable diets”: those diets with low environmental impacts that contribute to food and nutrition security and to healthy lives for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, are nutritionally adequate, safe, and healthy, and optimise natural and human resources (Burlingame and Dernini, 2012). As such, food sustainability should be viewed in two perspectives: production and consumption. The two notions are interconnected; food availability influences food choice, but at the same time the supply chain is also driven by consumer demands.

The current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100, according to a recent United Nations report (UN, 2017). Population growth projections for the next few decades highlight the urgent need for improving our food system in terms of nutritional quality and environmental sustainability (Johnston et al., 2014). This is further complicated by the challenges imposed by climate change and agriculture intensification. Increasing demand for the consumption of the most resource-intensive food types and its associated logistics and storage, especially in developing economies, will further increase the negative impacts of food and agriculture industry on environmental degradation and climate change (Government Office for Science, 2011). Food consumption patterns in a developing nation are often unbalanced: overconsumption and food waste coexist with undernutrition. In a global context, dubbed as the "triple burden", more than 1.9 billion people worldwide were overweight and obese in 2014 (WHO, 2016) while 795 million people suffer from hunger (FAO et al., 2015), and another 2 billion suffer from "hidden hunger", i.e. micronutrient deficiencies (FAO, 2013).

Alongside modernisation and increased incomes in the developing nation, there is a rising demand (appetite) for oil, salt and processed foods as well as environmentally costly animal source foods (e.g. dairy and meat) (Godfray et al., 2010; Government Office for Science, 2011). Meanwhile, the globalisation of the food system has increased the affordability of energy-dense, nutrient-poor food while further contributes to environmental degradation and biodiversity loss (Government Office for Science, 2011). Coupled with physical inactivity and sedentary lifestyles, there is an unprecedented rise in obesity and non-communicable diseases, such as cardiovascular disease, diabetes, and hypertension (Johnston et al., 2014). These health issues were once confined to high-income countries, but have now become increasingly prevalent across low- and middle-income countries indiscriminately (Alleyne et al., 2013).

In Malaysia, for example, the economy has changed remarkably over the past 30 to 40 years. GDP per capita increased dramatically since the 1970s, achieving an average GDP growth rate of 6.8% per annum during the 1970-2015 periods (DoSM, 2016). In tandem with GDP growth, the

Malaysian population experienced rapid urbanisation and growth of household income. The annual growth of mean household income was about 11% in the 1990s and 9% annually since the 2000s up to 2014. Similar to the situation discussed earlier in developing nation, Malaysia recorded an alarming obesity rate with the 2015 statistics showing that the overweight and the obese make up nearly half of its populace. It was also revealed that 47.7 and 30.3 per cent of adults in the country had high cholesterol and hypertension in 2015 (Institute of Public Health, 2015). While obesity and metabolic risks are increasingly prevalent among Malaysian adults, undernutrition still prevails, especially in the younger population. According to the latest statistics from the National Health Morbidity Survey (NHMS 2015) (Institute of Public Health, 2015), more than 7% of children in Malaysia under 5 had been identified as overweight. The same survey also found that 8% of children under 5 suffered acute malnutrition, or wasting. Another study found high proportions of underweight (49 %) and stunted (64 %) children in aborigines' (*Orang Asli)* villages (Wong et al., 2015).

Given the increasing prevalence of both the obesity epidemic and non-communicable diseases, there is a compelling need for a closer examination of the nutrition and health transition in Malaysia. As seen in reports by Godfray et al. (2010) and Government Office for Science (2011) that were discussed earlier, the health problems faced in Malaysia are very likely a result of a change in diet. This would be characterised by increased consumption of processed food and animal protein that threatens the sustainability of healthy diet. Understanding the emerging trends, provides the essential prerequisite information required to solve the bigger problem: how sustainable diet can be assessed within both the local and global food system, and how environmental sustainability can be achieved within population consumption patterns and dietary goals.

1.1.1 Indicators for Sustainable Consumption

It is challenging to define a sustainable diet in practice as there is not yet an agreed approach or tool to determine the level of sustainability of a diet or the trade-offs associated with any attempts to increase the sustainability of a diet (Johnston et al., 2014). Many assessment methods and indicators have been proposed, but most of them have been performed with specific reference to the Mediterranean diet. There has been no attempt to carry this out in the developing countries yet. In the context of sustainable consumption, indicators are necessary to monitor time-trends to determine whether a population's consumption leads to more socially equitable and environmentally sustainable development (Donini et al., 2016). Indicators are also essential to evaluate the impact of dietary patterns on long-term health status, and particularly on the pathogenesis and prevalence of non-communicable diseases (Donini et al., 2016). Some of the indicators proposed by Donini et al., (2016) include:

- Plant and animal protein consumption ratios
- Average dietary energy adequacy
- Dietary energy and nutrient density score
- Dietary diversity score
- Adherence to local foods and seasonality
- Eco-friendly production and consumption
- Diet-related morbidity and mortality statistics
- Nutritional anthropometry
- Adherence to the Mediterranean dietary pattern

Indicators are usually estimated from information collected through detailed Individual Dietary Surveys (IDS) (usually Food Frequency Questionnaires (FFQ) or repeated measures of 24-hour recall dietary questionnaires), Household Budget Surveys (HBS), and food balance sheets (FBS) (Donini et al., 2016). Each of these varies in the methodology that leads to different levels of disaggregation and detail. As the first step, reliable information about nutritional status and food consumption pattern is essential to identify nutrition patterns that threaten health, food security and sustainability. At the population level, statistical databases, such as the food balance sheets (FBS) of the Food and Agriculture Organisation (FAO), provide a rough overview of nutritional supply, but more detailed information on the actual food intake can only be gained from individual dietary surveys (Elmadfa and Meyer, 2014). Better knowledge of the relationships between diets and the sustainability of the food system, and proper tools and indicators taking into account the human and food systems dimensions of sustainable diets, are very important to determine the priorities for action (Li, 2016).

The previous-indicated approach has been very valuable in order to express the whole of a dietary pattern. The limitation is that usually cut-off points used in most scores are sample-dependent, making the interpretation of any identified association of this pattern with health outcomes difficult to generalise (Donini et al., 2016). Second, since many indexes exist, a natural question is whether some work better than others with respect to capturing the adherence to an ideal sustainable diet (the Mediterranean diet in most case studies), as well as, to identifying associations of this diet with a specific health outcome (Donini et al., 2016). However, to decide which of these indexes is "optimal" is rather difficult, since such a decision would require one to evaluate the predictive ability of the various indexes with respect to different outcomes using one population, and then validate the results to different populations (Donini et al., 2016). It is further complicated by the common use of population-specific but not universal cut-off values for discriminating the low/high consumptions for each of the components of a sustainable diet (Donini et al., 2016). The sustainability assessment for individual food items, especially fish consumption, is challenging. Unlike other animal protein sources, there is a wide array of fish types available for consumption and each type should expectedly differ in some indicators of sustainability due to the specificity of fisheries. Correctly determining whether fish is sustainable or not is challenging as it relies on the knowledge of how the species is fished, the fishing equipment used, origin or location of wild-catch or the particular farming method used (Klein and Ferrari 2012).

As mentioned before, most of the assessment methods and indicators have been proposed with specific reference to the Mediterranean diet. The Mediterranean diet is considered as a healthy dietary pattern and a greater adherence to the Mediterranean diet has been associated with better health and nutritional status (FAO, 2015). It has also been recognised as a sustainable diet because of its lower environmental impact (FAO, 2015). The traditional Mediterranean dietary pattern put great emphasis on local and eco-friendly products; it includes an abundance of olive oil and olives, fruits, vegetables, whole grains, legumes, nuts and fish, moderate amounts of dairy products (preferably cheese and yoghurt) and low quantities of meat and meat products (Bach-Faig et al., 2011). The adherence to Mediterranean diet may not be the best indicator for a sustainable diet in Malaysia. Olive oil and olive, for example, are not native products of Malaysia. Importing these products would encounter high "food miles" and defeats the very purpose of practicing a sustainable diet. Nonetheless, the plant-based dietary pattern of a Mediterranean diet has advantageous nutritional, economic and environmental characteristics that make it relevant for a case study to characterise sustainable diets in different agro-ecological zones (FAO, 2015).

1.2 THE IMPORTANCE OF FISH IN THE LIVELIHOOD OF MALAYSIANS

The Food and Agriculture Organisation (FAO) and Department of Fisheries Malaysia (DoFM) estimated per caput supply put Malaysians among the world's top fish consumers, even ahead of Japan: the FAO estimated 52.1 kg per caput supply of fish for direct human consumption in 2005 (FAO, 2009) while the DoFM reported that the fish supply per capita was 46 kg in 2010, with a projected increase to 55 kg by 2020 (DoFM, 2015). In fact, the largest proportion (around 20%) of Malaysian food and non-alcoholic beverages expenditure were spent on fish (DoSM, 2016). There are three main drivers that could explain such high consumption of fish among Malaysian: geography, resources and social and cultural heritage. Geographically, Malaysia is a country with a long coastline, which is about 4,800 km in length (EPU, 1992). Malaysia's warm tropical seas are home to some of the richest coral reefs, mangrove forests and other marine species. Being a relatively poor country then, fish was a natural life line for the majority of Malaysia population, particularly for coastal communities that depended almost exclusively on fisheries and related activities for livelihoods and for nutrition. Today, after a few decades of rapid economic development, Malaysia is an upper-middle income country. Despite that, the fisheries sector is still an important sub-sector in Malaysia and plays an integral role in the Malaysian society. Apart from contributing to the national Gross Domestic Product (GDP), fisheries provide an affordable source of protein and are crucial sources of income and employment in rural coastal fishing villages throughout the country, both historically and in present time (Raduan et al., 2007; Teh and Teh, 2014).

On the other hand there were cultural influences since Malaysia is a multi-racial and multi-religious country. As of 2010, about 60 % of its 28.3 million people were Malays, followed by Chinese (22.5%), Indians (6.8%) and other minority races (10.7%) (DoSM, 2016). Islam was the most widely professed religion in Malaysia with the proportion of 61.3%. Other religions embraced were Buddhism (19.8%), Christianity (9.2%) and Hinduism (6.3%) (DoSM, 2016). Redkar and Bose (2004) reported that religion had a significant impact on households' fish purchasing decisions. Due to religious observances, pork is forbidden in the Muslims' diet while the Hindus are prohibited from consuming beef. Whilst animal protein consumption is dependent on the religious fabrics of the population, fish is basically acceptable to all irrespective of cultural backgrounds. Thus, fish tends to dominate over other animal protein sources in this country. Fish features prominently in the Malaysian diet. The Malaysian culinary traditions are linked to habits of eating pelagic fish, small indigenous fish (eaten whole with bones), and different fish, such as prawn and cockles. The abundant fish is also preserved by processing them into fermented or salted fish, pickles and traditional "surimi" products (i.e. a variety of popular food products such as fish ball, fish cakes, "lekor" crackers, fish fingers, fish sausage).

The fact that fishery resources are an important source of nutrients for human is well known. Fish provides high quality protein that can significantly improve the quality of dietary protein intake by complementing the essential amino acids that are often absent or present in low quantities in the staple food in diets typical of many developing states (FAO, 2004). For instance, fish is particularly rich in the essential amino acid lysine which is often deficient in rice diets with little animal protein (FAO, 2004). Fish oils are the richest source of dietary n-3 fatty acids that are vital for brain development and cognition in the foetus and infants (Sheila, 2007). This makes all fish and especially fatty fish particularly good components of the diet during pregnancy and the first two years of life. The function of fish, in particular oily fish, in lowering the risk of coronary heart disease (CHD) mortality is evident in adults (Kris-Etherton et al., 2003). Fish is also an important provider of a range of micronutrients not widely available from other sources in the staple diets of the rural or poor. With respect to micronutrients contribution, the size of the fish and the plate waste are important factors. This is particularly true for small sized species that are consumed whole, with heads and bones. These species can be excellent sources of many essential minerals such as iodine, selenium, zinc, iron, calcium, phosphorus and potassium, but also vitamins such as A and D, and several vitamins from the B-group, if prepared with suitable cooking methods (Kawarazuka, 2010). Meanwhile, shellfish such as mussels, shrimps, crab, and other crustaceans and molluscs also contain considerably high concentrations of carotenoids (Britton et al., 2009), low levels of fat and essential amino acids (Holland et al., 1993) and also possess a relatively higher content of vitamins and minerals (Caballero, 2009).

Fish plays very different roles in the diet of the world's populations. In developing populations, the focus has been on the role of fish in tackling undernutrition and improving food security. Meat from terrestrial animals is generally more expensive than the low-value/small fish; therefore, the poor remain dependent on small pelagic fish. The significant contribution of small fish to the micronutrients intake in the diets of Malaysian rural population can be demonstrated by the differences in daily intake of anchovy between rural and urban populations. Anchovy (*Stolephorus indicus*), which is generally eaten whole in the Malaysian diet, was reported to be significantly higher among the rural compared to the urban adults (Norimah et al., 2008).

In developed populations, the focus has been on fish as a healthy alternative to other sources of protein, especially red meat, due to the high levels of polyunsaturated fatty acids in fish and fish oils (especially from marine sources). This is especially useful in the Malaysian context as it was found that in 2015, 47.7 and 30.3 per cent of adults in the country had high cholesterol and hypertension (Ministry of Health Malaysia, 2015). A related trend amongst developed populations is the increased demand for fish oil supplements. Although exact statistics are not readily available, this phenomenon can be observed in Malaysia, especially in the urban area – where plenty of fish oil supplements can be seen sold over the shelves. Popular personal care chained stores in Malaysia, e.g. Guardian and Watson's, stock more than 10 brands, each carrying a wide array of fish and krill oil supplements.

1.3 FISH CONSUMPTION PATTERN IN MALAYSIA

Consumers' dietary choices are one of the most important determinants for the sustainability of food systems. Modifying unsustainable dietary habits can be extremely beneficial for the environment (Pelletier et al., 2011). Unfortunately, Malaysian fish consumption habit is not well studied. The Malaysian Adult Nutrition Survey (MANS) provided the first national estimates of energy and nutrient intakes (Mirnalini et al., 2012), food consumption patterns (Norimah et al., 2008) and meal patterns (Abdul Manan et al., 2012) of the Malaysian adult population but did not provide insight into the quantifiable contribution of the different types of fish and shellfish to energy and nutrient intakes of its respondents. The most relevant information pertaining fish and shellfish consumption were that i) marine fish (one medium fish per day) was consumed daily; and that ii) the mean frequencies for daily intake of marine fish and anchovy (ikan bilis) were significantly higher among the rural compared to the urban adults whereas more urban dwellers consumed chicken and eggs more frequently than their rural counterparts.

In 2008, a group of researchers funded by the Ministry of Health Malaysia conducted a cross-sectional survey to investigate patterns of fish consumption among Malaysian adults in Peninsular Malaysia using a 3-day prospective food diary (Ahmad et al., 2016). The study subjects (n= 2675) were comprised of 14.7% Chinese, 8.3% Indian and 77% Malay. Overall, the subjects consumed 168 g/day (61.3 kg/year) of fish, far exceeding the estimated amount of supply made by the FAO and Department of Fishery Malaysia. Not only that, because the questionnaire was self-administered across all research settings (i.e. rural and urban), there was a high tendency of reporting error. Mis-reporters were also not identified and energy-adjustment was not made. Similar to MANS, marine fish was also identified as the major type of fish consumed. However, the limitation of this study was the poor response to the type of fish consumed because 40% of the fish consumption records did not mention the fish by name. Therefore, the calculation for fish consumption data were only included in the total fish consumption but not species specific. The researchers identified that this data deficiency might be due to the inability of the study subjects to recall fish name. Although direct and indirect evidences show that Malaysia is a high fish consumer nation, no study has yet to investigate the sustainability of this consumption habit.

1.4 FISH PURCHASING BEHAVIOUR OF MALAYSIANS

Malaysian household fish expenditure was analysed in two studies conducted about ten years apart. These studies utilised some unique large dataset from the 1998/1999 (Tan et al., 2005) and 2009/2010 (Tan et al., 2015) Malaysian Household Expenditure Survey (MHES). With a total of 9198 (Tan et al., 2005) and 21641 (Tan et al., 2005) households being surveyed using a stratified multi-stage, area probability sampling method, the samples in these studies reflected the Malaysian population. Both studies observed comparatively similar trends in expenditure pattern.

Expenditure patterns of fish products were to found to vary considerably across different age and ethnic groups in Malaysia. As attested in both Malaysian studies, older households, led by mature (age 46-59) and retired (age > 60) persons, consistently exhibited higher purchase likelihood and levels of expenditures on all three fish products compared to younger-middle age (30-45 years) households. The reverse is true, as younger (age 18-29) households were less likely to purchase and also spend less on fish products than older households (Tan et al., 2005; Tan et al., 2015). One commonly cited hypothesis for these higher probabilities and expenditure levels among older households is that individuals tend to be more health conscious as they age and are more inclined to purchase more healthful foods (e.g., fish products). However, the fact that consumption of processed fish that is infamously linked to health issues was higher in older households provides proof of contradiction. It was consistently found in both Malaysian studies that ethnicity had a significant influence on the amount of spending and types of fish purchased. Malay households spent, on average, more on fresh fish (RM69.41) than Chinese (RM66.95) and Indian (RM60.11) households per month. For shellfish, average monthly expenditures of Chinese households (RM40.47) outweighed those of Malay (RM31.21) and Indian (RM29.95) households. Expenditures on processed fish were dominated by Indian (RM 18.26) compared to Malay (RM16.73) and Chinese (RM 16.80) households. This suggests a possible preference for fresh fish among the Malay households, while the Chinese favour shellfish and Indians processed fish (Tan et al., 2015). These results suggest that the heritage of food culture specific to each community is an enduring influence.

The earlier Malaysian study revealed that education level was negatively related to expenditure levels, though statistically insignificant (Tan et al., 2005) whereas in the recent study, expenditure level was significantly associated with education for certain fish products and ethnic groups only (Tan et al., 2015). For example, Malay households with tertiary educated household heads were marginally less likely to purchase fresh fish and shellfish and spend less, respectively, than secondary/high school-educated Malays. Chinese households headed by individuals educated at the primary level spent more on fresh fish and processed fish than their high-school educated counterparts. Within Indian households, only lower-educated individuals spent less on shellfish compared to others, all else constant. Tertiary education did not affect purchase or level decision among the Chinese and Indians. Foreign researchers have contrasting opinions on whether education level plays a direct role on the frequency of consumption of fish dishes. For instance, a Norwegian study found that those with some university education appeared to have higher consumption rates for fish dishes than do those with between 10 and 12 years of education (Myrland et al., 2000). On the other hand, Verbeke and Vackier (2005) reported that although higher education resulted in a higher intention to eat fish, there was no significant and direct effect on the consumption frequency itself.

Tan et al. (2015) also found that urbanisation had a significant influence on fish purchasing behaviour among certain ethnic groups in Malaysia. Malays and Chinese in urban areas displayed lower purchase likelihood and also procured less fresh fish than their rural cohorts. Such negative effects of urbanisation were evident in the likelihood of purchasing processed fish and expenditures on fish by urban Malay households, but not among the Chinese and Indians. Urban Indian households were 4.0% less likely to purchase fresh fish than their rural cohorts. Foreign researches have also confirmed that people in different regions tend to differ in their cultures, traditions, socio-economic status, attitudes, and thus, quantities of fish consumed and preference for species vary also (Needham and Funge-Smith, 2014). A positive and statistically significant relationship between monthly household income and expenditures on fish products was consistently found in both Malaysian studies. It was suggested that fish products is a staple item in Malaysian household because its consumption is not affected by the increasing household financial burden as income increases (Tan et al., 2005; Tan et al., 2015).

A few other Malaysian studies have looked into the determinants that affect consumers' purchase decision at point of purchase. These determinants are generally the intrinsic and extrinsic attributes of fish and its products. Freshness, taste, availability, nutritional value and price were commonly found to be important factors that influence the purchasing of fish in Malaysia. In a recent urban study, Ahmed et al. (2011) administered structured questionnaires on 700 randomly selected respondents or households around the Kuala Lumpur area, in Peninsular Malaysia. Generally, the importance of each determinant in fresh fish purchasing decision was ranked uniformly across respondents of different ethnic and education background. The highest ranked factor was price (68.6%), followed by freshness (67.8%). Taste was also considered to be an important factor when purchasing fresh fish, where a fairly large proportion of the respondents (44.1%) indicated this factor was important. A further 41.6% of the consumers agreed that the nutritional value was one of the most important factors to be considered when purchasing fresh fish. Household meal planners who were concerned about the undesirable nutrition values of other meats, such as saturated fat and cholesterol, had a positive attitude toward fish, especially the presence of Omega-3. They were likely to buy fresh fish more than once a week compared to those who were not concerned. Other factors that influenced purchasing behaviour were a high percentage of edible flesh (42.4%), availability for purchase (38.4%) and few bones (32.2%). Family preference for a particular type of fish was also reported to be an important factor by 40% of the respondents. Ease of preparation or cooking and the colour of the fish were not very important factors for the respondents when considering purchasing fresh fish.

In another study by Hanis et al. (2013), a total of 202 respondents from the capital cities of all states in Malaysia were interviewed to elicit their preferences for marine fish attributes. The finding was consistent with that of Ahmed et al. (2011) that freshness was rated the most important attribute (59.79%) among a total of fifteen hypothetical attributes sought after by respondents. Packaging was ranked second (22.27%) and location was ranked third (17.94%). A dated urban survey revealed that urbanites in Malaysia preferred fish with an affordable price tag and suitable size (Osman et al., 2001). In this short survey, 10 species of fish most commonly used in the everyday diet were identified. The Indian mackerel (*Rastrelliger kanagurta*) was ranked the most popular fish due to its low cost and suitable size. In a similar study conducted on Kuala Lumpur households using structured questionnaires, 700 respondents were randomly interviewed with regard to their buying behaviour pattern, attitude and perception on fresh marine fish consumption. It was found that the size and income of the households, gender, taste and the nutritional value of fresh fish significantly influenced the purchasing behaviour of the respondents (Ahmed et al., 2011).

Findings from overseas studies echoed with those of Malaysian studies. In a nutshell, perceived quality (Spinks and Bose, 2002; Trondsen et al., 2003; Verbeke and Vackier, 2005), and health benefits (Trondsen et al., 2003; Verbeke and Vackier, 2005) were significant characteristics forming a positive attitude toward eating fish; whereas some other attributes like the doubts about storage and the danger of food poisoning (Leek et al., 2000), the smell and bones of fish had only negative effect on fish preference (Leek et al., 2000; Olsen, 2001; Verbeke and Vackier, 2005; Nguyen and Olsen, 2012). Perceived difficulty to cook and prepare fish as a meal (Spinks and Bose, 2002) and the availability of fish (Myrland et al., 2000) were also found to be a significant barrier. Those who had little confidence in their fish quality evaluation abilities had lower likelihood to purchase fish (Verbeke et al., 2007).

1.5 STATUS OF MALAYSIAN FISHERY INDUSTRY

The Malaysian fisheries sector consists of three main subsectors, namely marine capture fisheries, aquaculture, and inland fisheries. Both capture fisheries and aquaculture contributed to most of the country's fish production. The inland fisheries are insignificant. Malaysia does not have large river systems, or natural lakes, and with increasing industrialisation, many of the river systems are being polluted (FAO, 2009). There is probably not much scope for further expansion. Recreational fishing is reportedly growing in Malaysia, but there is very limited information on the marine recreational fishing industry in terms of participation rate and fishing effort (Teh and Teh, 2014).

1.5.1 Marine Capture Fisheries

Malaysia's marine fisheries are primarily coastal (30 nautical miles from shore), and can be split into two sectors – "traditional" (i.e., small-scale) and "commercial" (i.e., industrial) (Teh and Teh, 2014). Coastal and deep sea fisheries contribute about 70% of the country's fish production (DoFM, 2009-2014). Marine capture fisheries in Malaysia are multi-species. For the purpose of statistical collection, Department of Fisheries Malaysia (DoFM) categorises species caught into over 100 "groups". A "group" may include over 10 species. Hence, over a thousand fish species could occur in the catches. While both pelagic and demersal species are targeted, pelagic formed the mainstay of fisheries on both coasts of Peninsular Malaysia in the early period (Pathansali 1961; Pong 1992), and continue to make up substantial portions of marine landings (up to 40% in 2010). Several "groups" of pelagic fish like mackerels and scads consistently dominate the catches, with just one or two demersal fish "groups" like rays appearing in the list of dominant groups (FAO, 2009).

Table 1: The quantity of marine fish landed in Malaysia from year 2009 to 2014 (Source: Compiled from annual fishery landing data published by Department of Fisheries Malaysia (DoFM), 2009 – 2014)

Year / Quantity ('000 mt)	2009	2010	2011	2012	2013	2014
Total Marine Fish Landed	1393	1429	1373	1472	1483	1390
Deep Sea	297	320	287	336	326	278
Coastal	1097	1109	1086	1136	1157	1111

Table 1 shows the quantity of marine fish landed in Malaysia from year 2009 to 2014. While the number of marine fish landed remained constant over the 5-year course, fishing effort over the same period had reportedly increased. The number of fishing license had increased by 15% from 2009 to 2014. Coastal fisheries remained the most important marine capture fisheries as it accounted for about 75% of the total marine fish landed.

1.5.2 Aquaculture

Aquaculture contributes about 30% of the country's fish production. Aquaculture is split between brackish water and freshwater production. In 2014, brackishwater aquaculture contributed almost four times more (417,000 metric ton) than freshwater production (115,000 metric ton) (Table 2). The major production of brackish species comprised of 66% of seaweed, followed by Vannamei prawn (*Penaeus vannamei*) (12.3%), barramundi (*Lates calcarifer*) (7.4%) and blood cockles (*Anadara granosa*) (4.3%) (DoFM, 2014). High value marine fish, e.g. groupers (*Epinephelinae spp.*), comprised of the remaining 10% of total brackish water production volume (DoFM, 2014). Production of the exotic whiteleg shrimp (*Penaeus vannamei*), introduced from the Pacific sometime in 1995, began in 2001 when the marine shrimp production showed a sharp increase of almost 70% compared to 2000 (FAO, 2009). Blood cockles (*Anadara granosa*) are endemic to Malaysia, particularly in the west coast of Peninsular Malaysia (FAO, 2009). The culture of barramundi (*Lates calcarifer*) in floating net-cages started in the 1980's and became commercialised in the mid 1990's (FAO, 2009). Of the commercially cultured freshwater species, catfish (*Siluriformes*) accounts for 45.2% of the total freshwater aquaculture production, followed by red tilapia (*Oreochromis spp.*) (27.0%) and carps (*Cyprinus spp.*) (10.1%) (DoFM, 2014).

Table 2: The quantity of farmed fish produced in Malaysia from year 2009 to 2014 (Source: Compiled from annual aquaculture production data published by Department of Fisheries Malaysia (DoFM), 2009 – 2014)

Year	2009	2010	2011	2012	2013	2014
Total Aquaculture Production Quantity ('000 mt)	472	581	527	634	530	532
Freshwater						
Quantity ('000 mt)	153	155	122	164	133	115
Value (RM Million)	704.28	760.34	684.15	992.39	880.45	759.44
Brackish						
Quantity ('000 mt)	320	426	404	471	397	417
Value (RM Million)	1,618.61	2,038.40	2,371.94	1,765.71	1,808.26	2,086.35

1.5.3 Post-Harvest Utilisation

Freshly caught marine fish are chilled on-board the harvest vessel. Commercial vessels are fitted with refrigeration systems, while traditional fishermen commonly use ice (FAO, 2009). At landing points, fish are generally auctioned to wholesalers. The Fisheries Development Authority of Malaysia (FDAM) has fish landing complexes in major landing ports that act as auctioneer to ensure fair prices to the fishermen. The chilled fish are then sent to major wholesale centres for retailing in the wet market. Due to increased modernisation, fish are also being channelled to the supermarket chains in major towns to cater for the needs of a more sophisticated population. In the event of harvest surplus, fish is put into frozen storage. Some aquaculturists sell their products in live form directly to restaurants in bid for higher profit than in conventional markets. However, the market for live fish is small, and most farmed fish is marketed in chilled form (FAO, 2009).

Fish processing such as the making of salted fish, fish crackers, fish balls and cakes, and ethnic condiments like shrimp paste (*belacan*), pickled shrimp (*chincaluk*), fish sauce and fermented fish (*budu*), is a traditional family-own and managed simple production in coastal villages. However, there has been an increasing trend towards commercial operations with industrial scale set-ups (FAO, 2009). The trash fish and bycatch are transformed into fishmeal to be incorporated into animal feed, including fish and shrimp feed. The marine aquaculture industry has been dependent on the supply of trash fish as fish food (FAO, 2009). With an estimated fish production of about 500,000 tonnes annually (Table 2), and assuming a feed conversion ratio of 8 to 1 (FAO, 2009), a minimum amount of 4,000,000 tonnes of trash fish could be needed. However, the actual amount of trash fish needed is likely to be less than predicted numbers as some fish farmers prefer formulated feed, while others are likely to use a mixture of trash fish and formulated feed (FAO, 2009).

1.5.4 Assessing the Sustainability of Fishery Production

The first step to making the notion of sustainable development operational is to understand its definition. There are definitions available from international bodies with particular relevance to fisheries and marine resources. Sustainable development has been defined by FAO as "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable" (FAO Council, 1989).

Currently, there are sustainable fish certification (or eco-label) programs aimed at increasing consumer awareness of the sustainability and environmental impact of their fish choices. These certification programs are also important tools for assessing social accountability. One of the well-known certification programs is Marine Stewardship Council's scheme. Other programs include regional guides, such as that produced by the Australian Marine Conservation Society (AMCS) and Canadian's SeaChoice. The assessment methods of these certification programs use robust criteria that usually consider three main factors: species, ecology and management. Different types of fish species differ in many inherent factors such as growth rate, age at maturity and longevity that dictate the inherent vulnerability of a fish species. The sustainability of fish is not only species and geographically specific, but is also highly dependent on the production practices. Fishing practices and the use different gear types can have different effects on habitats, ecosystems and the bycatch. Effective management and governance via regulations, monitoring and enforcement is important for maintaining fish sustainability.

Eco-labelled fish is popularly used in developed countries to address public concerns about the ecological sustainability of fish harvesting. Consumers who value sustainable harvesting highly demand eco-labelled fish (Johnston et al., 2001). In a UK study, the presence of a label conveying that the fish came from a sustainably managed fishery increased the probability of this product (cod fillets) being chosen by 6.61%. Similarly, the probability of a tin of tuna or a salmon steak being chosen was also increased by over 5% through the presence of the 'sustainability' label (Jaffry et al., 2004). A study that investigated Japanese consumers' willingness to pay for Marine Stewardship Council (MSC) eco-labelled fish found that there was a statistically significant premium of about 20 per cent for MSC-eco-labelled salmon over non-labelled salmon when consumers were provided information on both the status of global fish stocks and the purpose of the MSC program (Uchida et al., 2014). Mainland Chinese consumers were also willing to pay more for the eco-labelled fish for the protection of societal benefits. Fifty-three percent of the Mainland Chinese respondents who indicated a willingness to pay a premium for eco-labelled fish were willing to pay a small premium of 1 – 6% and 35% were willing to pay a larger premium of 10 or more percent (Xu et al., 2012).

On the other hand, a Flemish study showed that many consumers underestimated the ecological impact of animal production (Vanhonacker et al., 2013). Well-known alternatives such as organic meat, moderation of meat consumption and sustainable fish were accepted, although willingness to pay was apparently lower than willingness to consume. Consumers were more reluctant to alternatives that (partly) ban or replace meat in the meal. While Verbeke et al. (2007) found that consumer attached high perceived importance to sustainability and ethics related to fish, this perceived importance was neither correlated with fish consumption frequency nor with general attitude toward eating fish. Refusing to eat wild fish was found to be grounded in sustainability and ethical concerns, whereas the decision not to eat farmed fish was associated with a lower expected intrinsic quality rather than shaped by importance attached to sustainability and ethical issue (Verbeke et al., 2007).

1.5.5 The (Un)Sustainability of The Wild Fish Supply

In line with population growth, since 2000 the annual average increment of fish consumption in Malaysia has been constant at about 1.6% (Abu Bakar et al., 2013) but actual annual fishery landings in Malaysia do not observe a similar growth trend (DoSM, 2016). To cater for increasing demand, fish landings (national data) in Peninsular Malaysia increased by over 300% between 1960 and 1980 (Teh and Teh, 2014). By the late 1970s, the trawl sector was already overexploited (Mohd Taupek 2003) as trash fish made up an increasing proportion of total fish landings (Mohammad Arriff and Mohammad Raduan 2009). In the mid-1980s, with inshore fisheries showing signs of strain, the Malaysian government started to encourage deep sea fishing in waters beyond 30 nautical miles from the coast (Teh and Teh, 2014). Fish landing statistics from 2000-2010 show an increasing temporal trend for marine fish landings, the proportion of commercial food fish in the landings has declined, whereas trash fish made up on average 30% of total landings in Peninsular Malaysia. Fish catches have remained fairly stable over time because when the coastal maritime regions were fished out, the fisheries spread out into new areas and into ever-deeper waters to yield more catch. Fewer regions are left out of reach for fish to reproduce undisturbed, thus creating a positive feedback loop on the effects of over-harvesting.

Prior to the late 1970s, trash fish that is usually a bycatch in trawl fisheries were mostly discarded at sea due to lack of commercial value (Abu Talib et al., 2003). However, since the late 1970s the majority of trash fish have been landed due to the high demand from fishmeal manufacturers and marine aquaculture industries (Teh and Teh, 2014). The trash fish is often composed of a substantial proportion of juveniles of commercial food fish. Although zoning system was introduced in an attempt to ensure the sustainability of the fishery resources, the protective effect of the zoning system was not prominent because the Fishery Act 1985 (Act 317) only forbids trawlers from fishing in Zone A (5 miles from the shore reserved for small fishermen) (CAP, 2011). In a plea to fully ban trawl fishery in 2011, The Consumer Association of Penang conducted a survey to prove its stand. One kilogram of trash fish was purchased from fisherman and the trash fish were separated according to species. Hundreds of juvenile fish of 10 different types were found in the sample. A large proportion of the trash fish were made up of the commercially important Indian mackerel (*Rastrelliger kanagurta*). On average, there are about 6 mature mackerels in a kilogram. The Indian Mackerels found in the sample were so small that 900 of these fish only weighed 1 kg. If those 900 juvenile mackerel were allowed to grow to maturity, they would weigh 150 kg. In other words, up to 150 kg of fish, that could otherwise be used for human consumption, would be potentially lost by every 1 kg of trash fish captured (CAP, 2011).

In recent years, climate change has been linked to an increase in atmospheric carbon dioxide, UV irradiation, and ocean temperatures that ultimately results in a decrease in marine phytoplankton growth and in the synthesis of omega-3 polyunsaturated fatty acids (PUFAs) (Kang, 2011). Since marine phytoplankton are the primary producers of omega-3 PUFAs, these detrimental effects of climate change may reduce the availability of omega-3 PUFAs in our diets, exacerbating the modern deficiency of omega-3 PUFAs and imbalance of the tissue omega-6/omega-3 PUFA ratio, which have been associated with an increased risk for a number of non-communicable diseases (Kang, 2011). Combining data on dietary nutrition and fish catch, Golden et al. (2016) predict that more than 10% of the global population could face micronutrient and fatty-acid deficiencies driven by fish declines over the coming decades, especially in the low latitude developing nations (including

Malaysia). The populations in these countries are most nutritionally dependent on wild fish, but at the same time are also most at risk from illegal fishing, weak governance, poor knowledge of stock status, population pressures and climate change (Golden et al., 2016).

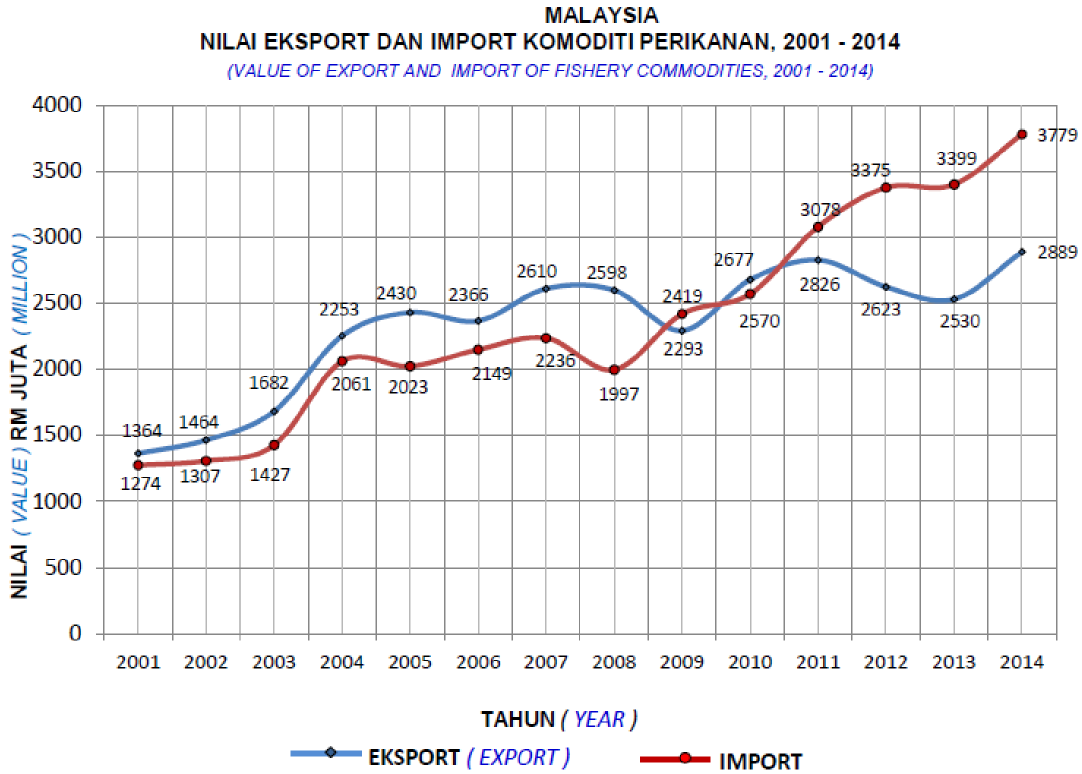
Relative to recent decades, Cheung et al. (2016) predicted that ocean warming and changes in net primary production would drive remaining fish and shellfish species from low to high latitudes, thus reducing global catch by more than 6% and by as much as 30% in the tropics by 2050. The reduction in sizes of fish are also forecasted as ocean warming and associated declines in oxygen content are projected to reduce the average biomass of fish communities by around 20% during this period (Cheung et al., 2013). Ocean warming and acidification will heavily degrade coral reefs, the essential ecosystems for many tropical coastal subsistence and artisanal fisheries (Golden et al., 2016). Mangroves — nurseries for many fish that are crucial in developing nations — are also rapidly declining (Golden et al., 2016). The decline in global inland freshwater fisheries as a result of climate change will threaten the crucial source of nutrition and livelihood for hundreds of millions of people, especially in the developing nations (Youn et al., 2014).

The degradation of marine habitat by destructive fishing practices (e.g. trawling), climate change, pollution and coastal development is likely to further degrade ocean ecosystems and reduce fisheries yields (Golden et al., 2016). It raises the question of whether wild fisheries will be able to support future demand for fish. Added to this constraint is the proportion of the fish catch that is transformed into fish meal and animal feed and thus is not available for human consumption. Postharvest loss, bycatches and discards of non-commercial species by capture fisheries also represent a potentially significant loss in the amount of landed fish. Also to be taken into account is that high value fish from Malaysia are exported to generate income while a portion of the fish consumed in Malaysia are imported from places such as Thailand and Indonesia (DoFM, 2014)). Concern over whether the marine catch fishery import-export transaction in Malaysia is able to sustain the increasing per capita fish consumption trend in the country is growing.

Malaysia has traditionally been a net exporter of fish, however, since after 2008, the trend reversed and imports outweighed exports, creating a negative and unfavourable balance of trade (Figure 1). In 2014, the import volume accounted for around 480,000 metric tons with an associated cost of RM 3,779 million. A significant portion of the imported fisheries commodities were wild marine fish (e.g. mackerels) from neighbouring countries such as Thailand and Indonesia (DoFM, 2014). Most of the freshwater aquaculture production such as the catfish, tilapia and carps are marketed locally for domestic consumption. As a source of income, Malaysia exports most of its high value farmed products to foreign market. Among the exported commodities are shrimp and high grade fish such as groupers and snappers. The bulk of these commodities are sent to United States followed by Singapore, Japan, EU and China (FAO, 2008-2017).

Figure 1: Value of export and import of fishery commodities, 2001 – 2014

(Source: DoFM, 2014)



In response to the overfishing of wild fish stocks and the increasing consumer demand for fish, consumers are now offered farmed fish as an alternative (Verbeke et al., 2007). However, aquaculture is still far from its full potential development as its production and development is imbalanced (FAO, 2008-2017). The potential of aquaculture industry in Malaysia is largely untapped. On average, 85% of fishery products in Malaysia consist of wild-caught marine fish while only 15% are from aquaculture farm, after taking away farmed seaweed (DoFM, 2009-2014). Aquaculture activities began to develop in Malaysia in the 1920s and are now increasing in importance (FAO, 2008-2017). In fact, it became a priority area in the government's recent policy programme for 1998-2010 which aimed at increasing aquaculture production by 200 % by 2010 (FAO, 2008-2017) but the aim is not quite achieved yet. There is very little published knowledge on the barriers and challenges faced by the Malaysian aquaculture industry. Feasibility research in the area of aquaculture activities should be given priority due to the emerging importance of aquaculture as an alternative source of fish supply and export income.

1.5.6 General Perceptions of Fish Farming and Farmed Fish

The development of aquaculture is dampened by the negative perceptions consumer have for fish from aquaculture, even if the perceptions are baseless (Bacher, 2015). Social science studies of aquaculture have generated increasing interest in recent years. Most of this research has focused on consumer attitudes towards aquaculture products (Verbeke et al., 2005; Verbeke and Vackier 2005; Verbeke et al., 2007; Vanhonacker et al., 2011; Hall and Amberg, 2013; Schlag and Ystgaard, 2013; Claret et al., 2014) and are focused on the main consumer markets of United States of America and European Union. Malaysian consumer beliefs and attitudes about cultured products have not yet been systematically examined. Nonetheless, these western studies consistently confirm the consumer's perception of fish as a healthy component of the human diet while there is gap between scientific evidence and consumer perceptions for the organoleptic attributes and nutritional value of fish. Considering the perception of fish products, majority of the consumers thought that wild-caught product tasted better than farm-raised ones but also admitted not being able to distinguish fish origin by taste alone. Consumers had even greater difficulty in recognising the fish origin on site (Gaviglio et al., 2009). European consumer studies showed that wild fish was associated with better taste (Verbeke et al., 2007), better quality (Verbeke et al., 2007; Claret et al., 2014) firmer texture, more nutritious and less fatty (Claret et al., 2014).

A qualitative exploratory study by Verbeke et al. (2007) showed that a lot of people seem to be prejudiced against farmed fish product. Their opinions were most likely due to emotions, parallel stereotypes being drawn with the production systems for other livestock and negative press coverage about the excessive use of preventative antibiotics and other chemicals. The norms and expectation from significant others had substantial influence on food purchasing behaviour of the consumer (Olsen, 2004; Verbeke and Vackier, 2005). Recent environmental groups (primarily against the salmon farming industry) may scare consumers away from farmed and towards wild-caught fish (Babcock and Weninger, 2004). Public health warnings from the EC Scientific Committee on Animal Nutrition, EC Scientific Committee on Food and the government of the UK on the consumption of fish fed with fishmeal and fish oil from contaminated areas (Staniford, 2002) would also lead consumers away from the farmed products.

This perception of wild fish being more 'natural' seems to idealise the naturalness of conventional fishing and contrast it with the idea of modern methods of aquaculture being unnatural (Schlag and Ystgaard, 2013). Such perception is evident among European consumers as they reportedly showed some reservations on the use of medicinal or growth promotion residues (Verbeke et al., 2007) and antibiotics (Gaviglio et al, 2009) in aquaculture activities. On the other hand, some consumers regarded farmed fish as less susceptible to marine pollution and heavy metals than their wild counterparts (Claret et al., 2014). Hence, consumers seem to face a trade-off between medicinal or health additive residues that were perceived to be prevalent in farmed fish, and pollutants and heavy metals that were perceived to be less present in farmed fish (Verbeke et al., 2007).

Knowledge about the fish and aquaculture practices is important in consumer selection of wild-caught versus farmed fish (Verbeke et al., 2007), especially if there is a concern over the adverse effects poor aquaculture practices can possibly bring. In many urban areas and developed countries, consumers are becoming more interested in the food they eat and are increasingly concerned with food production issues. Formation of new regulations related to agricultural traceability in some developed countries, intended to inform consumers about the origin (wild-caught or farmed), country of production or catch and the production process in order to obtain differentiation in price, provide evidence for variation of consumer willingness to pay for wild-caught versus farmed fish (Defrancesco, 2003).

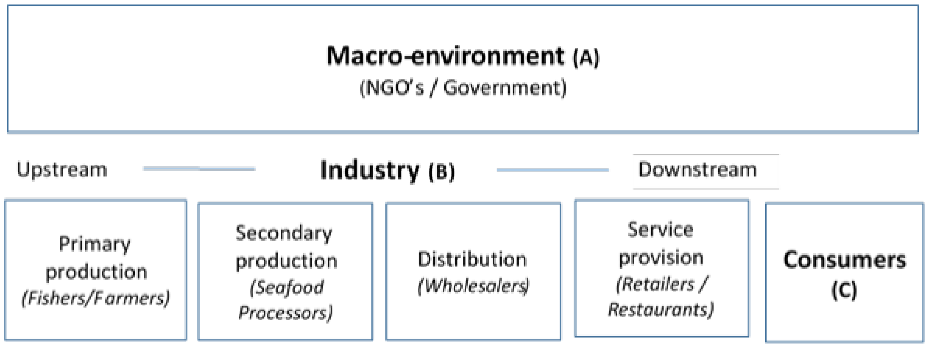
It was found that consumers with a higher willingness to purchase farmed fish were usually modern (Gaviglio et al., 2009) and younger in age (Vanhonacker et al., 2011; Polymeros et al., 2014; Polymeros et al., 2015). In addition, most of the consumers in this cluster had a higher level of education and declared a high monthly income. However, farmed fish consumers generally represented a lower fish consumption pattern (Vanhonacker et al., 2011; Polymeros et al., 2015). Some consumers preferred farm-raised fish simply for its cheaper price (Gaviglio et al., 2009). The price-sensitive cluster was characterised by middle-aged and young pensioners buying mainly at street markets, with small families, and medium-low educational qualification (Gaviglio et al., 2009).

Perceptions have also been shown to vary due to demographic characteristics such as gender, age and education. In an Australian study, women respondents were reportedly more concerned about the potential impacts of aquaculture and were more suspicious of both the government and the aquaculture industry (Mazur et al., 2005), whereas another Spanish study found that Spanish women were more open to aquaculture than their male counterparts (Claret et al., 2014). Moreover, people with higher levels of education in Australia were found to be more aware of issues affecting aquaculture and coastal management (Mazur et al., 2005). A study of Belgian consumers showed that the oldest respondents (over 55 years) held a stronger belief that wild fish is healthier and has a better taste than farmed fish (Verbeke et al., 2007). Similarly, Gaviglio et al. (2009) reported that older consumers in Italy purchased wild fish due to the hedonic experience of consuming traditional dishes. They typically did not care about the price of food, but they had a demand for specific products that they were used to eating (Gaviglio et al., 2009). Others, who were considered traditionalist, absolutely considered wild fish better than farmed fish based on deeply rooted prejudices that wild fish is better due to its more expensive price (Gaviglio et al., 2009).

Information from developing countries is sporadic and scarce. A couple of studies shows that consumers in Ghana (Darko, 2011) and Kenya (Githukia et al., 2014) preferred wild tilapia and catfish to farmed fish, primarily due to issues of availability, healthiness and taste. Consumers in Kenya stated a dislike for the 'mud taste' of farmed tilapia (Githukia et al., 2014). Some Kenyan consumers had health concerns arose from their perceptions that farmed fish were produced with genetically modified feed ingredients or chemicals such as growth hormones and pesticides (Githukia et al., 2014). Similarly, a study from Egypt suggested public concern about contaminants in locally farmed tilapia, resulting in preference for frozen imported fish (Eltholth et al., 2015). In countries where there is a lack of confidence in food safety regulatory systems, the safety and quality of food become the most important aspects associated with fish (Bacher, 2015). For example, safety and quality rather than price were considered the most important factors influencing the consumption of fish products in China (Zhang, 2002). Chinese consumers were reportedly willing to pay a price premium for products that had approval/recognition labels resulted from more rigorous food-safety inspection (Wang et al., 2009). To date, no known research has been conducted in Malaysia to investigate the general perception of fish farming and farmed fish of the population. Aquaculture is currently underutilised in Malaysia and has great potential to alleviate the tension on wild fish stock. The projected growth of this industry can only be realised if it is well received by consumers. Thus, the research priority is to understand their perceptions and identify any barriers to the expansion of the industry.

1.6 STAKEHOLDERS' ROLES IN FISH SUSTAINABILITY

Figure 2: Stakeholder Roles in Fish Sustainability (Source: Adapted from Lawley, 2014)



Stakeholder groups can be segregated into three different categories – Macro Environment (A), Industry (B) and the Consumers (C) (Figure 2). Government and Non-Governmental Organisations (NGOs) are the main stakeholder groups in the macro-environment (A) for fish sustainability, each with different roles. Governments play a role that focuses on the development and implementation of policy and regulation, as the only entities with the authority to regulate and enforce industry practice. Within Malaysia, there are two federal government stakeholders with a remit for fish. The Department of Fisheries Malaysia (DoFM) is under the Ministry of Agriculture Malaysia and is entrusted with the role of developing, managing and regulating the fisheries sector. The objectives of the DoFM are to increase the national fish production, manage the fisheries resources in a sustainable basis, develop a dynamic fisheries industry, intensify the development of fish-based industries and maximise the income of the fishing industry. The Fisheries Development Authority of Malaysia (FDAM) is a statutory body established in 1971 with the objective to upgrade the socio-economic status of the fishermen community in particular to enhance their income and to develop and expand the fishing industry (FAO, 2009).

Recently, both the intergovernmental bodies, the Association of Southeast Asian Nation (ASEAN) and the Southeast Asian Fisheries Development Centre (SEAFDEC), have agreed that sustainable practices in the region need to be improved. The ASEAN-SEAFDEC Member Countries ratified the Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating Illegal, Unreported and Unregulated (IUU) Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products (2016). This commitment was declared in response to the challenges of the changing environment and the emerging issues in the ASEAN region including climate change and the growing gap between the increased demand for fish and fishery products and ASEAN's ability to supply these products in a sustainable manner. This joint effort also took into account the imperative to minimise the impacts caused by the increasing pressures on fisheries and globalisation of trade that are resulting in increased illegal, unreported and unregulated (IUU) fishing, the depletion of coastal fish resources, habitat degradation, negative impacts of aquaculture, and increased conflicts among resource users that further jeopardise the food security and livelihoods of ASEAN people, in particular the poor and disadvantaged.

As noted in Lawley's paper (2014), NGOs are responsible in disseminating knowledge and acting as influencer, primarily to create a public good. The NGO group has additional internal complexity of roles and goals as they vary widely in terms of their degree of internationality, the breadth or specificity of their remit, and sources of funding, which all in turn influence their perspectives on fish sustainability (Lawley, 2014). As these NGOs have different sets of goal and objectives, their area of focus and definition of sustainability may vary. This stakeholder group includes broadly focused government-funded international bodies such as the FAO, international organisations with a single focus on conservation such as the WWF, as well as non-profit/charity organisations specifically focused on fish such as the Marine Stewardship Council, which are funded largely through accreditation work (Lawley, 2014).

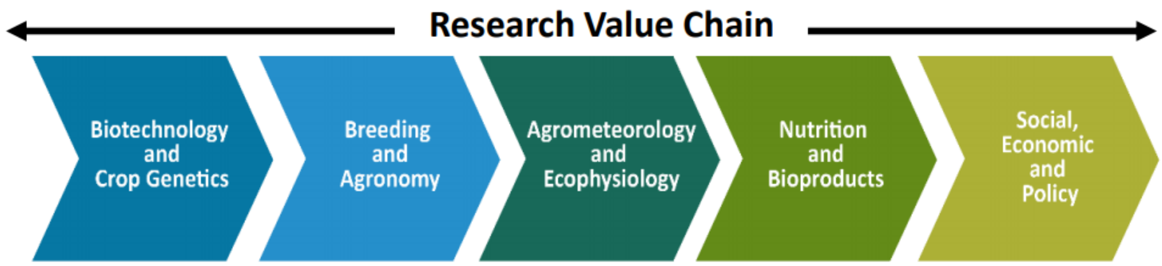
Industry value chain stakeholders (B) play a distinctive role in the production and delivery of fish products to end consumers. For example, those engaged in upstream, primary production activities are closest to the natural resource and include fish fishers and farmers. Fish processors and distributors then link with the service providers (retailers and restaurants) who deliver end products to consumers and are most influenced by consumer preferences and behaviours. While the clear majority of industry value chain stakeholders are for-profit organisations with profit-related goals, the competitive pressures and regulatory requirements, as well as how fish sustainability affects their roles, differ across steps in the value chain. The main motivation of fish primary producers (fishers and farmers) is to make a profit; however, motivations can differ depending on the size of the organisation and their ethical approach. For example, local, small scale fish producers are often family owned business whose members have grown up on the land. They rely on the land for their survival and as a result have a greater appreciation and concern for the environment and the impacts they are having. Larger producers may have a stronger focus on profits. Wholesalers have a major role in the marketing phase of the fish industry and can promote sustainable fish practices by ensuring their products are sourced from sustainable fish fisheries. Retailers have several roles related to fish – sourcing products and providing them to consumers, as well as marketing. In the food service sector in developed nations, sustainable fish is emerging as an important issue for many chefs and buyers (Lawley, 2014) but not so much so in Malaysia.

Consumers play a key role as decision maker in deciding whether and how to purchase fish, which directly affects the economic goals of industrial stakeholders. With the lack of consistency and clarity on sustainable fish, it is little wonder that consumers are generally ambivalent, lack knowledge and are confused (Lawley, 2014). Further, for many consumers sustainability is not of primary concern. Many retailers reported that the questions they were most commonly asked about fish were how to store and how to cook it, with many reporting they had never been asked about sustainability (Lawley, 2014). Consumers' attitudes are considered as one of the main determinants of food consumption behaviour (Shepherd and Raats, 1996; Homer and Kahle, 1988) because it influences on intention to buy food (Povey et al., 2001) and on actual consumption (Verbeke and Vackier, 2005). On the other hand, consumer knowledge was found to be an important determinant of fish choices as it is highly correlated with frequency of use and experience (Olsen, 2004).

1.7 ADDRESSING ISSUES OF SUSTAINABILITY IN THE AQUACULTURE SECTOR

Provision of fish meal is one of the limiting factors that limit development and compromised sustainability. The current dependence of Association of Southeast Asian Nations (ASEAN) aquaculture industries on feed derived from limited marine living resources and conventional plant species, that are external to the region, is unsustainable. This has prompted the establishment of FishPLUS program by the Crops for the Future Research Centre (CFFRC), in 2011 in Malaysia. The intended outcome of FishPLUS is for high quality, under-utilised plant-based aquaculture feed to be in abundant supply and used widely in targeted ASEAN countries. FishPLUS aims to develop innovative products to increase the nutritional value of aquaculture feeds for the ASEAN region. It explores the potential for Plant-Based Aquaculture Feed (PBAF) derived from under-utilised crops to partially or completely replace the ingredients currently obtained from major crop species and fishmeal. In addition, it assesses the role of PBAF in providing improved nutrition for aquaculture species.

Figure 3: CFF Research Value Chain (Source: CFF, 2015)



The CFF research programme spans research themes across a Research Value Chain (RVC) from fundamental genetics through to end users and policies. Detailed investigations are carried out using a `Research Value Chain' approach that combines activities across all five research themes and integrated knowledge systems and provides a generic methodology that can be applied to other underutilised crops. The five research themes are: (i) Biotechnology and Crop Genetics; (ii) Breeding and Agronomy; (iii) Agrometeorology and Ecophysiology; (iv) Nutrition and Bioproducts; and (iv) Social, Economic and Policy. While other research activities in the FishPLUS programme focus on incorporating underutilised crops into fish feed and protein outcome of fish, there is a research gap on the 4th and 5th research themes (RTs): Nutrition and Social, Economic and Policy. As have discussed in earlier sections, there are gaps in the literature on the status of Malaysian fish consumption and the potential barriers to increasing appropriately farmed fish in the diet of Malaysian population. The present thesis aims to address these knowledge gaps. The methodologies set out to achieve this aim are discussed in Chapter 2.

1. 8 THESIS OUTLINE

The thesis is structured in a "project portfolio" format. With the exception of Chapters 1 (General Introduction), 2 (Research Methodology and Design) and 7 (General Discussion and Conclusion), each study chapter has its own Introduction, Methods, Results, Discussion and Conclusion section, and can be read independently, Hence, some repetition can occur between chapters. The layout of the thesis is further described in section 2.7.

CHAPTER 2: RESEARCH METHODOLOGY AND DESIGN

2.1 INTRODUCTION

This chapter describes the research methodology adopted in this thesis. It first outlines the broader research question and the underlying research philosophy that underpins the approaches taken in these studies. This is followed by the problem statements and their respective operational definitions. It also provides an overview of the data collection methods used for each of the research questions, as well as the methods used to analyse the data. The chapter concludes with sections on ethical considerations and the rationale underpinning the choice of thesis layout.

2.2 RESEARCH PROBLEM AND APPROACH

This thesis focuses on addressing some of the key issues raised by the Fish PLUS programme of Crops For the Future (CFF). One of the broader research questions that was identified is 'to what extent is farmed fish capable of replacing wild-caught fish in the Malaysian diet?' After conducting a background literature review (Chapter 1), the subsequent research problem was outlined based on the assumptions that wild fish is the dominant type consumed in Malaysia and that the wild fish stock is depleting. Because detailed statistics were not readily available, it was essential for this study to assess the fish consumption habit in Malaysia and to identify signs of unsustainability. Once this was established, the next step was to carry out a market potential analysis to identify the key influencing factors and barriers to increasing consumption of farmed species. The research sits at the interface of two disciplines – nutritional science and marketing (social science). Because of the inter-disciplinary and multi-dimensional nature of the research, it was essential to make decisions on how these dimensions and their indicators were weighted to measure the composite interdisciplinary concept to get the required interdisciplinary measurements. This operationalisation procedure is known as the portfolio approach to widely defined measurements (Tobi, 2014). Only after the operationalisation of the concepts under study have been finalised, the research questions can be made operational.

The difficulty lay in determining whether, how, and what type of knowledge from both disciplines could be brought to bear in addressing the research problem. The knowledge required for solving food and nutrition problems could vary widely, depending on a variety of situational factors.

However, Pelletier (1997) suggested some generic categories of knowledge and skills relevant to this thesis, as follows:

- knowledge about the problem: its prevalence, distribution, and biological and behavioural causes;
- knowledge about local conditions - ecological, social, and economic - that may influence the adoption and effectiveness of various interventions; this includes, but is not limited to, the interests and perspectives of a variety of interested and affected parties;
- knowledge that will help anticipate the ecological, social, and economic consequences of alternative interventions; again, this includes, but is not limited to, the interests and perspectives of a variety of interested and affected parties;
- technical knowledge from whichever scientific disciplines are relevant, based on the biological and behavioural nature of the problem and the ecological, social, and economic assessment described above;
- the ability to integrate the knowledge, interests, and perspectives from all of the above, usually requiring an interactive or participatory process.

Adopting Pelletier's (1997) suggestions, this research was not driven by a particular scientific orientation and its associated methods. Instead, the intent was to take a pragmatic, problem-solving approach, allowing the development of holistic answers to research problems. This approach requires appropriate representation, involvement, or participation of the interested and affected parties (Pelletier, 1997). Instead of having the problem defined by professionals or technical experts via a linear planning and decision-making process, this approach is explicitly iterative in nature (Pelletier, 1997). This implies that traditional scientific properties, such as prediction and precision, should not be expected in all stages of the planning process. Instead, emphasis is placed on "creating a participatory process that will allow the relevant information on interests, values, obstacles, and consequences to surface so that they can be incorporated into the analysis" (Pelletier, 1997). It requires interchange of information between two distinctive but complementary processes: analysis and deliberation. Analysis refers to "the use of scientific methods for acquiring knowledge", whereas deliberation refers to "the methods by which people build understanding, reveal their interests and values, or reach consensus through discussion, reflection, persuasion, and other forms of communication" (Pelletier, 1997).

The operationalisation process needs to be pragmatic since the agreed research questions are central in selection of the data collection tools and methods (e.g., a cross-sectional study of inhabitants of a region, a laboratory experiment, a cohort study, a case control study, etc.), the so-called "study design". Typical study designs for descriptive research questions, such as those of this thesis, are the cross-sectional study design. The study design is to be further explicated by the number of data collection waves and the level of control by the researcher (Kumar, 2014). Then, decisions about the way data is to be collected, e.g., by means of certified instruments, are to be made. Depending on whether a suitable measurement instrument is available and matches with the interdisciplinary operationalisations from the conceptual design, the researcher may or may not need to design instruments. Instrument design can be in different forms, such as the design of a questionnaire or a part thereof, an interview guide with topics or questions for the interviewees, or a data extraction form in the context of secondary analysis and literature review (e.g., the Cochrane Collaboration aiming at health and medical sciences or the Campbell Collaboration aiming at evidence based policies) (Tobi, 2017).

The subsequent data analysis plan describes how data will be analysed, for each of the separate components of research methods and for the project at large. In addition to the plans at modular level, the data analysis plan must describe how the input from the separate components, i.e. different analyses, will be synthesised to answer the overall research question (Tobi, 2017). In case of mixed methods research, the particular type of mixed methods design chosen describes how, when, and to what extent the researcher will synthesise the results from the different components (Tobi, 2017). Similar to the quantitative data analysis plan, the qualitative data analysis plan presents the description of how the researcher will get acquainted with the data collected. Additionally, the rules to decide on data saturation need be presented. Finally, the types of qualitative analyses are to be described in the data analysis plan. Because there is little or no standardised terminology in qualitative data analysis, it is important to include a precise description as well as references to the works that describe the method intended (Tobi, 2017).

To fully optimise the results of interdisciplinary study, the components need to be brought together in the integration stage. The components may be mono- or interdisciplinary and may rely on quantitative, qualitative or mixed methods approaches. Subsets of components can be designed as convergent, sequential or embedded (adapted from mixed methods design by Creswell and Plano Clark, 2011). Convergent components, whether mono or interdisciplinary, may be done parallel and are integrated after completion. Sequential components are done after one another and the results from the first component inform the latter ones. Embedded components are intertwined. Here, components depend on one another for data collection and analysis, and synthesis may be planned both during and after completion of the embedded components.

2.3 RESEARCH QUESTIONS AND OPERATIONAL DEFINITIONS

The overall aim of this thesis is to address the research problem: "Is farmed fish capable of replacing wild-caught fish in the Malaysian diet?". In order to address this problem, a series of research questions were framed, as follows:

(R1) What is the fish-eating habit in Malaysia?

Operational definition: Eating habit is defined as the way individuals or groups of people eat, what they eat, how they eat and when. It includes intake frequency, diet composition and food choices of individuals.

(R2) Is their fish consumption habit sustainable?

Operational definition: Sustainability of consumption is adapted from the Oslo definition (Ministry of the Environment Norway, 1994) and is defined as "the consumption behaviour which responds to basic needs and brings a better quality of life while minimizing the use of natural resources and toxic materials as well as emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations."

(R3) What are the barriers and opportunities for expansion of the aquaculture market in Malaysia?

Operational definition: The reason behind industry members' perceived ease or difficulty to popularise farmed fish.

(R4) What is the fish purchasing behaviour of consumers in Malaysia?

Operational definition: Frequency of total fish consumption, prevalence of farmed fish consumption, preference (i.e. inclination to buy) of fish (whether wild or farmed), and stimulants or barriers that influence buying decisions.

(R5) What are the public perceptions of farmed fish?

Operational definition: The individual's positive, negative or neutral evaluation of quality attributes of farmed fish, based on personal emotion or experience and is not necessarily true or accurate.

2.4 STUDY DESIGN

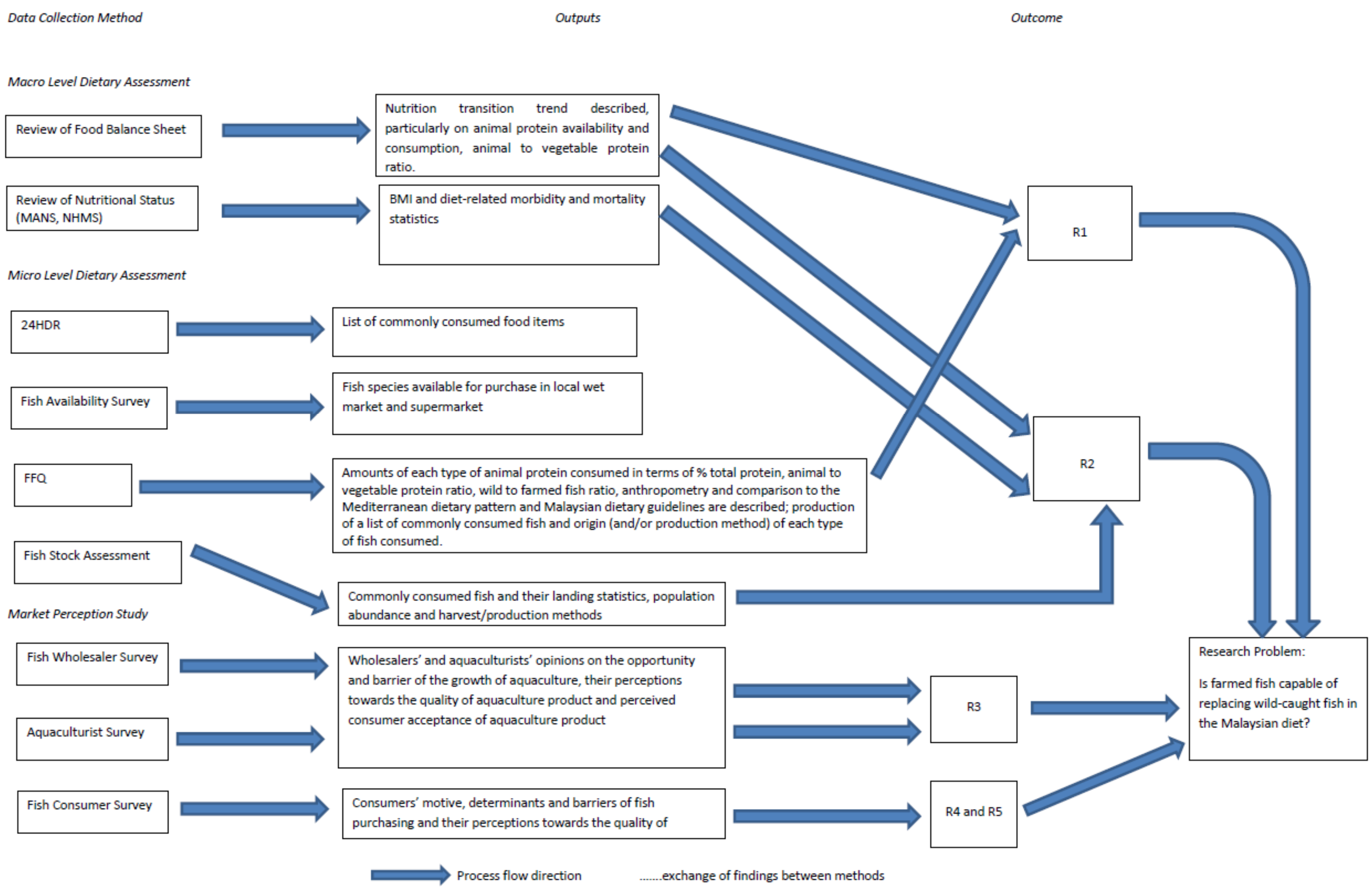
The study design (Figure 4) was the general plan that was used to answer the research questions. It refers to the overall strategy that was chosen to integrate the different components of the study in a coherent and logical way, thereby ensuring that the research problem would be effectively addressed; it constitutes the blueprint for the collection, measurement, and analysis of data.

The research questions in this study were inextricably interrelated. This interrelationship has been highlighted in one of the earliest and most influential models of determinants of food consumption behaviour proposed by Pilgrim (1957). In his model, Pilgrim acknowledged that the operational definition of food acceptance is food consumption while food consumption is dependent on perception. Hence, there were significant exchanges of findings between methods, i.e. findings synthesised from one method were used to inform another method(s), and vice versa. The summary of process flow in this research can be seen in Figure 4. The methods used to answer each research question are discussed in the following subsections.

2.4.1 (R1) What is The Fish-eating Habit in Malaysia?

As mentioned in section 2.3, the operational definition of eating habit was defined as "the way individuals or a group of people eats, what they eat, how they eat and when. It includes intake frequency, diet composition and food choices of individuals".

Figure 4: Summary of process flow and exchange of findings between methods



It was apparent that dietary assessment surveys were the most suitable method to answer R1. Since there are a multitude of dietary assessment tools available, the following section systematically evaluates the suitability of each tool and the rationale behind the selection of FFQ, followed by the process of development of FFQ to be used in current study.

2.4.1.1 Selecting Tool for Dietary Assessment

In general, the procedure for dietary assessment involves obtaining a report of all food consumed by an individual in terms of the portion size and the frequency of consumption of each food. Nutrient intake is computed by multiplying the portion size of each food item consumed with its consumption frequency and the nutrient content per gram of food. The methods for assessing individual dietary intakes can be broadly classified into two main categories, i.e. the retrospective reporting of intake and the prospective recording of consumption. In each of these two categories, several subcategories exist, as shown in Table 3.

Table 3: Typology of individual dietary survey methods

Prospective method	**Retrospective method**
Dietary or food records	Dietary history 24-hour dietary recall (24HDR) Food frequency questionnaire (FFQ)

Each of these methods has its own strengths and limitations, and the choice of one or the other method must be made according to the specific needs of the study. But regardless, all dietary assessment methods inherently have random (non-systematic) or biased (systematic) error (Rossato et al., 2014). Random errors are accidents such as skipping questions and may occur across all subjects. Systematic errors refer to misreporting intakes or respondent bias due to social desirability or approval. (Rossato et al., 2014)

2.4.1.1.1 Dietary (or Food) Records

The two approaches of food records are estimated food records and weighed food records. In both types of food records, subjects record the total amount of all foods and beverages (ideally at the time of consumption) consumed over a specified time period. In weighed food records, the subjects weigh all foods and beverages prior to consumption whereas in estimated food records, subjects estimate the amount consumed based on common household measuring cups and spoons, scales, food models or pictures. Respondents are usually trained, in advance, to do a food record (Wrieden et al., 2003; Thompson et al., 2013).

Since recording foods when consumed does not rely on memory, this method increases the chance of providing more accurate portion sizes, lessening the problem of omission and providing greater food detail. On the other hand, subjects may delay recording intake, therefore increasing their reliance on memory. Subjects may also change their eating habits or decrease the amounts consumed to simplify the measuring or weighing process. Food records have higher respondent burden than 24-hour dietary recalls (Wrieden et al., 2003), therefore require subjects to be highly motivated, trained and literate, which may limit the use of this dietary assessment technique in some populations (Thompson et al., 2013).

2.4.1.1.2 Dietary History (Burke Diet History)

In 1947, Burke introduced the dietary history method in an attempt to estimate an individual's usual food intake, which includes characteristics of the foods, and meal patterns over an extensive period of time. There are three components to this approach: (i) an interview obtaining a usual pattern of eating, including detailed food descriptions, frequency of consumption and usual portion sizes expressed in common household measures; (ii) a questionnaire that assesses the consumption frequency of certain foods; and (iii) a three day food record. Both the second and third component serve as a quality control cross-check to assure the internal consistency of the first component. (reference)

One of the strengths of the dietary history method lies in its ability to assess the whole diet, thus allowing the investigator to gain a more representative pattern than other methods of diet assessment in the past (Fagúndez et al., 2015). Protocols for this type of dietary assessment vary and a unanimous standard has not been established, hence the comparability of the data is not epidemiologically viable. Another disadvantage is that interviews can last for long hours which can be labour intensive and may be tiring for the respondent (Fagúndez et al., 2015).

2.4.1.1.3 Twenty-four Hour Recall Method

In a 24-hour dietary recall, subjects are asked by a "trained" interviewer to recall and report their intake, including all food and beverages, consumed in the previous 24 hours (Wrieden et al., 2003; Thompson et al., 2013). This method is subject to its primary limitation i.e. large within-person variations; hence, multiple recalls are required for a more accurate account. On top of that, taking into account any effects that different days have on food or nutrient intakes, recalls collected should reflect all days of the week (Thompson et al., 2013).

There are advantages and disadvantages to this dietary assessment method. It is less burdensome to subjects and they are not required to be literate because it is interviewer-administered. Recalls have less potential to induce change in dietary behaviour since they occur after the food has been consumed. However, the main disadvantage of 24-hour dietary recalls is that it is memory dependent; subjects may not accurately report their food intake, and may not be able to judge the portion sizes accurately. Single observation provides poor measure of consumption habits (Wrieden et al., 2003) and multiple recalls require substantial staff time (and costs) for interviewing, coding, processing, and quality control (Thompson et al., 2013).

2.4.1.1.4 Food Frequency Questionnaire

The food frequency questionnaire (FFQ) attempts to assess subject's "usual" intake over a long duration e.g. past 12 months (Wrieden et al., 2003; Thompson et al., 2013). The simplest FFQ consists of a list of foods that ask for frequency of consumption while the more sophisticated ones include prompts for portion sizes. Nutrient intake estimates are computed by adding the products of the reported frequency weight of each food by the amount of nutrient in a reported serving of that food, to produce an estimated daily intake of nutrients. Among the available dietary assessment tools, the FFQ has been widely used in large epidemiological studies. Various FFQ have been developed; some well-known American FFQs are the Block Food Frequency Questionnaires and the Harvard University Food Frequency Questionnaires or Willett Questionnaires (Coulston et al., 2013).

FFQ is researcher-friendly and presents minimal burden to the respondents. Because the FFQ asks for retrospective information, changes in diet among respondents can be avoided. However, similar to 24hr, it is memory-dependent and heavily relies on the ability of the respondent to judge for portion size. Subjects whose diet was not stable, e.g., individuals sometimes intentionally changed their diets, or are undergoing changes, due to pregnancy, illness or economic uncertainties, would be problematic. FFQs may not provide estimation of absolute nutrient intake, due to lack of specificity and detail, when compared to 24 hour recalls and diet records. Rather, nutrient intake as measured by an FFQ should be considered an “approximation” (Wrieden et al., 2003).

Most dietary methods for estimating food intake at the individual level have been designed for operating in highly literate developed nations. Some dietary assessment methods can be too burdensome for use in developing countries, or even in rural areas of some developed countries (FAO, 2003). Among the many difficulties and constraints to conduct a dietary survey in developing nations such as Malaysia that researchers should be aware of are: the culturally specific ways of acquiring, handling and sharing of food; the level of literacy in the sample population; culturally derived reluctance or straight-up unwillingness to participate in surveys; and local taboos or other rules that cause embarrassment and shyness (FAO, 2003).

When designing a study to assess the food intake of a large population sample, particularly in developing countries, the most accurate methods for assessing individual dietary intakes i.e. weighed dietary survey, chemical analysis of dietary duplicates, would be unsuitable because of the respective costs and logistics of implementation that arise from the scale of the sample size (FAO, 2003). The most approachable method in developing nations might be the FFQ because of its relative affordability, apparent simplicity and practicality (FAO, 2003). Usual intake, defined as the long-term average intake of a nutrient by an individual, would require many days of intake data and thus is costly and time consuming (Murphy et al., 2012).

In the context of the current study, where we are interested in assessing the breadth and extent of fish consumption (including the amounts and types of fish consumed), it is almost impossible to assess individual habitual intake of different animal products with the 24-hour dietary recall method The fact that there are many different types of fish being consumed further complicates the problem. Usual long-term food intake information could only be collected directly from each individual by asking about usual intake from a list of foods using instruments such as the FFQ. For this reason, the FFQ was selected as one of the tools for data collection pertaining to dietary habit. However, it should be noted that the FFQ is the least robust method, and much work still needs to be done to adapt it to different geographic and cultural situations depending on the needs of each survey (FAO, 2003). Experts suggest that an FFQ should be culturally and population specific (Thompson et al., 2013). Willet (1998) suggests if an FFQ has been created for a different population than what is being studied, the addition of some population specific foods to the existing questionnaire, may be desirable.

2.4.1.2 Adaptation of the FFQ

After considering the aforementioned factors and evaluating available resources, an existing validated FFQ developed by the University of Science, Malaysia (USMFFQ) was adopted for the current study. The design and methods are described in more detail elsewhere (Loy et al., 2011). Briefly, the USMFFQ, with identified standard portion sizes, was developed to assess the dietary habit of the Malay ethnic in the past 12 months. A total of 177 subjects participated in the validation study while 85 of them participated in the reproducibility study which was carried out in the Universiti Sains Malaysia Hospital. The newly developed USMFFQ was validated against two 24-hour dietary recalls. The USMFFQ was repeated 20 to 28 days apart. On average, at least 90% of subjects were correctly classified into the quartiles for nutrients and foods from the two sets of the USMFFQ. The USMFFQ presented acceptable reproducibility and appears to be a valid tool. The USMFFQ had to be adapted for use in the current study in the following ways:

(1) to consider the food intake of the Malaysian adult population which comprises the three main ethnic groups of Malaysia - Malays, Chinese and Indian ethnic groups, a cross-culturally robust food list has to be developed;

(2) fish was generalised and assessed as one food item on the food list of USMFFQ.

Ngo et al. (2009) summarised the key components addressed in the adaptation of study instruments and methodologies. For those studies adapting a previously validated FFQ, researchers derived information directly from target ethnic groups via direct consultation with the target ethnic groups by collecting 24-hour dietary recall or food records or via in-depth semi-structured interviews or focus groups. In the context of the current study, a single 24-hour dietary recall survey (Appendix A, B and C) was conducted among 80 adults, age 18 – 60 years, in the urban Klang Valley (n=20), rural Hulu Selangor (n=40) and coastal Kuala Selangor (n=20). Unlike validation that requires minimal within-person variation, and therefore requiring multiple questionnaires to eliminate the unexplained variation, pooled data were used in the current study, thereby alleviating the need for multiple interviews.

A total of 208 food items were pooled from these 24-hour dietary recall subjects. The food items were cross-checked against those listed in USMFFQ. Unlisted food items were selected based on a 15% frequency cut-off (Ferreira et al., 2010). Subjects of 24-hour dietary recall who reported to have consumed fish were asked to name the species of fish consumed, with support of fish photographs. On top of that, a fish availability survey was conducted. The names of fish species sold at various grocers, markets and restaurants in Klang Valley and Selangor were recorded. A comprehensive list of fish species commonly available and consumed was generated. To categorise the items on the list as wild or farmed, assumption had to be made based on comparison of data of capture fishery landing and seedling hatchery. Aquaculture consultants, fish suppliers and fishmongers were consulted to confirm whether the wild and farmed fish were appropriately categorised.

For feasibility reasons and to reduce the burden imposed on subjects, the resultant food list was further reduced to a nested list by aggregating conceptually similar foods on the basis of their nutrient content per portion eaten. The final compiled FFQ food list (Appendix D) had 148 items categorised under 12 main food groups, which were: (1) Cereals and cereal products; (2) Meat and meat products; (3) Fish and seafood; (4) Eggs; (5) Legumes and pulses; (6) Milk and dairy products; (7) Vegetables; (8) Fruits; (9) Beverages; (10) Confections; (11) Bread spread; (12) Condiments. Summary questions on overall intake of each one of the twelve food groups were added to the FFQ for cross checking purposes. The frequency of intake was based on habitual intake over the past twelve months. There were four options in the category for frequency of intake, which were 'per day', 'per week', 'per month' and 'never'. As an interviewer administered semi quantitative FFQ, subjects were asked to estimate the number of portion size consumed relative to the portion size measurement photograph in the Malaysian Atlas of Food Exchanges and Portion Sizes (Shahar et al., 2009) (Appendix E and F).

For data analysis, descriptive statistical techniques were used to examine differences in nutrient and food intakes across population subgroups. Descriptive analyses compare differences across subgroups in means, medians, percentages, and proportion with intake less than or exceeding the recommended guidelines.

2.4.1.3 Validity of Food Frequency Questionnaires Measuring Fish Intake

A biomarker is often considered a "gold standard" to validate a dietary assessment tool. A suitable biomarker should have a strong direct and independent relationship with the nutrient or food group of interest (Brantsaeter et al., 2010). Various validation studies employed the use of an independent biomarker (i.e. plasma phospholipid omega-3 PUFAs) to test detailed food frequency questionnaires of fish consumption but those studies have tended to be conducted in countries with higher consumption of cold water fish (Mina et al., 2007). Previous studies that have assessed oily and lean fish separately have found that consumption of oily fish, but not lean, has a significant correlation with omega-3 PUFAs (Svensson et al., 1993; Hjartaker et al., 1997; Bjerregaard et al., 2010). Mina et al. (2007) went a step further to reveal a significant negative correlation between lean fish and plasma omega-3. Another important drawback is the invasive nature of plasma biomarker sampling, which can be difficult to administrate. Hence, biomarker was not chosen for the validation purpose.

Other validation approaches include external validity and construct validity. External validity of a study or relationship implies generalisability to an external population. Researchers who studied the pattern of fish intake validated their study by comparing fish consumption frequency against the data from existing national studies (Verbeke et al., 2005; Verbeke et al., 2007; Pieniak et al., 2008). Construct validity can be described as the degree to which the data collected reflect or measure the variable of interest. Content validity is a critical step and can be described as judgments by experts about the ability of a measuring instrument to function as intended while face validity is the subjective judgment on the operationalisation of a construct, as perceived by respondents (Ngo et al., 2009).

Several approaches were used to validate the adapted FFQ used in this study, namely, content validity, face validity and external validity. Three local nutritionists reviewed the FFQ to confirm content validity in November 2015. Comprehensive coverage of the newly developed FFQ was evaluated a sub sample of 20 subjects. Appropriate adjustments were made based on the feedback received. In order to check the external validity of the data, the characteristics of the current survey population were compared with similar data recently obtained by other sources. Neither the most common reference methods to validate an FFQ, i.e. diet records nor 24-hour dietary recall, was employed due to consideration of follow up rate.

2.4.2 (R2) Is Their Fish Consumption Habit Sustainable?

As there was not yet a universal approach or tool to determine the level of sustainability of a diet, indicators that were proposed by an International Working Group from different national and international institutions (Donini et al., 2016) were adopted for this study. Referring to the aforementioned operational definition of R2, multidimensional indicators concerning the adequacy of diet in relation to health and environmental sustainability were selected (Table 4). Special emphasis was also given to the capacity of the ecological system to continuously preserve the resource base for the production and consumption activities of future generations. While indicators are usually estimated from information collected through detailed individual dietary surveys (IDS) (usually FFQ), and food balance sheets (FBS) (Donini et al., 2016), for this study, additional information was collected via a systematic literature review. For instance, fisheries-related statistics and diet-related morbidity and mortality statistics were not readily available through FFQ and FBS, hence were collected from other sources, e.g. Department of Fisheries, National Healthy and Morbidity Survey (NHMS) and Malaysian Adult Nutrition Survey (MANS) (Table 4).

Table 4: Sustainability indicators and their respective sources of information

Indicators (Adopted from Donini et al., 2016)	**Source of information**
Plant and animal (fish) protein consumption ratios	FFQ (current study); Food Balance Sheets (FAO, 2017a)
Average dietary energy adequacy	FFQ (current study); Food Balance Sheets (FAO, 2017a)
Adherence to local fish and seasonality	FFQ (current study); Landing statistics by species & Import/export statistics by species (DoFM, 2000 – 2014)
Eco-friendliness of fish production	FFQ (current study); International Union for Conservation of Nature (IUCN) Red list database (IUCN, 1964 – 2017); Fishing /Farming practices by species (DoFM, 2000 – 2014)
Diet-related morbidity and mortality statistics	MANS & NHMS (Institute of Public Health, 2014 – 2017)
Nutritional anthropometry	FFQ (current study); MANS & NHMS (Institute of Public Health, 2014 – 2017)

Extant data analysis is a form of qualitative research in which documents are interpreted by the researcher to give voice and meaning to an assessment topic (Bowen, 2009). Extensive analysis of public records, scholarly articles, journal and book publications was carried out to complement the findings generated from the use of data collection tools such as interview, observation or questionnaire. This exercise aimed to triangulate the findings or provide a different lens or perspective to validate the findings from the other instruments. For research question R3, the information or data relevant to the indicators listed in Table 4 were extracted from multiple sources. Patterns of fishery resource use that threaten the current or future capacity to meet human needs while preserving the environment, were identified and discussed.

2.4.3 (R3) What are The Barriers and Opportunities for Expansion of The Aquaculture Market?

The semi-structured interview was chosen as the method to answer this research question. Semi-structured interviews are commonly used in exploratory studies to provide further information about the research area (Harvard University, 2001). Semi-structured questionnaire that allows for extra information prompting would be more suitable for the exploratory nature of R3. The semi-structured questionnaires included a mixture of open and close ended questions.

In order to elicit an overall view of the industry, the subjects interviewed were both aquaculturists and wholesalers. The retailers were not included because it was thought that their narrow market experience may not be relevant to the highly segmented market. As aquaculturists and wholesalers are of different business natures, one set of semi-structured questions was customised specifically for each of the marketers, but both sets shared similar measures for R3. The questionnaires were designed to collect and collate their opinions on the opportunities and barriers to the growth of the aquaculture industry, their perceptions towards the quality of aquaculture products, and their perceived consumer acceptance of aquaculture products. The measures of each topic were summarised as follows:

a. Perceived opportunities and barriers related to the production and/or marketing of farmed fish

For aquaculturists: *"If you were to double the size of your aquaculture business, what do you think are the barriers that you have to first overcome?" "What are the existing or emerging trends and factors that you think are exploitable opportunities to help expand your aquaculture business?"*

For wholesalers: *"If you wanted to double the sales (start selling) of farmed aquatic animal* *products, what do you think are the barriers that you have to overcome?" "What are the existing or emerging trends and factors that you think are exploitable opportunities to help increase the sales of your farmed products?"*

b. Perceived customers' preference

For both aquaculturists and wholesalers: "*I noticed that you said more customers prefer wild-caught aquatic animal than farmed aquatic animal. Why do you think more customers would prefer wild-caught aquatic animal than farmed aquatic animal?" Or*
"I noticed that you said more customers prefer farmed aquatic animal than wild-caught aquatic animal. Why do you think more customers would prefer farmed caught aquatic animal than wild caught aquatic animal?" Or
"I noticed that you said customers prefer wild-caught aquatic animal as much as farmed aquatic animal. What are the reasons you think customer preference in wild-caught or farmed aquatic animal is indifferent?"

c. Perceptions of aquaculture products from the wholesalers' point of view, in terms of various product attributes as compared to wild fish.

Twelve quality attributes were used to assess the perceptions of farmed versus wild fish.. The attributes were adapted from previous studies (Verbeke et al., 2007; Claret et al., 2014): freshness, quality, smell, taste, texture, availability throughout the year, price stability throughout the year, state of being "premium", value for money, health benefits, contaminant content and lastly sustainability. Respondents were required to answer whether fish of wild or farmed origin was superior in each of the attributes. Two other response categories, i.e. "no difference" and "don't know", were included to better segregate the respondents' standpoints and avoid forced choice bias.

Data collection from respondents ended once data saturation was achieved for open-ended questions, i.e. when interviews did not provide any new or additional insights because the information gathered was repetitive. After each interview, the researcher searched for new themes, and looked out for novel ways of perceiving situations. With thematic analysis, the open-ended data was reworked or ‘reduced’ to represent major themes or categories that describe the phenomenon being studied. In this way the coding frame was continuously developed in response to new information until the point where new interviews did not provide any new themes relevant to the research focus. At this point theoretical saturation was said to be reached. Closed-ended responses were summarised and presented in frequency tables.

2.4.4 (R4) What is The Fish Purchasing Behaviour in Malaysia?

A structured questionnaire was developed to solve research question R4. Based on past literature (Verbeke et al., 2005; Verbeke and Vackier 2005; Verbeke et al., 2007; Vanhonacker et al., 2011; Hall and Amberg, 2013; Schlag and Ystgaard, 2013; Claret et al., 2014), four measures were designed in line with the operational definition and categorisation of variables in a way that the fish purchasing behaviour of Malaysians could be clearly described.

i. Assessment of the consumption frequency of farmed fish and total fish

First, a fish availability survey was conducted. The names of fish species sold at various grocers, markets and restaurants were recorded. A comprehensive list of fish species commonly available and consumed was generated. To select predominantly farmed species from the list, assumption had to be made based on analysis of data of capture fishery landing and seedling hatchery. Aquaculture consultants, fish suppliers and fishmongers were consulted to confirm that the selected list of farmed fish species was appropriate.

Fish consumption behaviour was a self-reported measure. Two questions probed the frequency of fish consumption, both at home and out of home. The responses were summated in order to create one final variable, namely, total fish consumption. The frequency scale had 6 points, which were “seldom/never”, “2-5 times every 6 months”, “1-3 times a month”, “1-2 times a week”, “3-5 times a week” and “more than 5 times a week”. Further on, with the same scale, the respondents were asked to report how frequently they consume each of the farmed species as listed.

ii. Assessment of the determinants at point of purchase

Nine items that assess influences of determinants at point of purchase were selected. These are ‘freshness”, “price”, “nutritional value”, “familiarity”, “cooking plan”, “sustainability”, “information of product origin”, “level of contaminants”, and “presence of “muddy” smell”. Consumers were asked to rate each item with a 4-point Likert scale that ranged from “no influence” to “extreme influence”. A neutral response category was not included, which forced respondents to think and make up their mind about the proposed statements.

iii. Assessment of the g motives to eat fish

There were 9 items that assess motives that drive fish purchase and consumption, i.e. “personal liking”, “family member’s liking”, “advice of health professionals”, “cheap price”, “family habit”, “for a varied diet”, “easiness to prepare”, and “customs and traditions”. Consumers rated each motive with a 4-point Likert scale that ranged from “no influence” to “extreme influence”. A neutral response category was not included, which forced respondents to think and make up their mind about the proposed statements.

iv. Assessment of the barriers to consumption

There were 13 items that assess level of influences of barriers to fish purchase and consumption. Most of the barriers were the opposite statements of motives, i.e. “personal disliking”, “family member’s disliking”, “perceived unhealthiness of some fish”, “advice of health professional to reduce consumption of certain fish” and “expensive price”. Other barriers included were “the lack of experience in judging freshness, cleaning and cooking of fish”, “unpleasant smell when cooking”, “lower satiety compared to meat”, “abundance of bone”, “inconsistent supply of fresh produce”, and “limited choices”. Similarly, consumers were asked to rate each motive with a 4-point Likert scale that ranged from “no influence” to “extreme influence”. A neutral response category was not included, which forced respondents to think and make up their mind about the proposed statements.

For data analysis, mean scores and standard deviations on 4-point scales, as well as frequency distributions, were calculated. Nonparametric bivariate analyses through correlation and comparison of mean scores, i.e. Wilcoxon– Mann–Whitney test and analysis of variance F-tests with Dunnett T-3 post hoc comparison of mean scores, were used to detect differences in frequency of consumption between different sociodemographic and behavioural consumer groups.

2.4.5 (R5) What are The Public Perceptions of Farmed Fish?

The public perceptions of farmed fish were measured through a consumer survey with structured questionnaire. Perceptions of farmed versus wild fish on 12 attributes were assessed in the questionnaire. The attributes were adapted from previous studies (Verbeke et al., 2007; Claret et al., 2014): “freshness”, “quality”, “smell”, “taste”, “texture”, “availability throughout the year”, “price stability throughout the year”, “state of being “premium””, “value for money”, “health benefits”, “contaminant content” and lastly “sustainability”. Respondents were required to answer whether fish of which wild or farmed origin was superior in each of the attributes. Two other response categories, i.e. “no difference” and “don’t know”, were included to better segregate the respondents’ standpoints and avoid forced choice bias. For data analysis, descriptive statistical techniques were used to compare differences across subgroups in percentages and proportion of different response categories for each of the 12 attributes.

2.5 SELECTION OF THE STUDY AREA

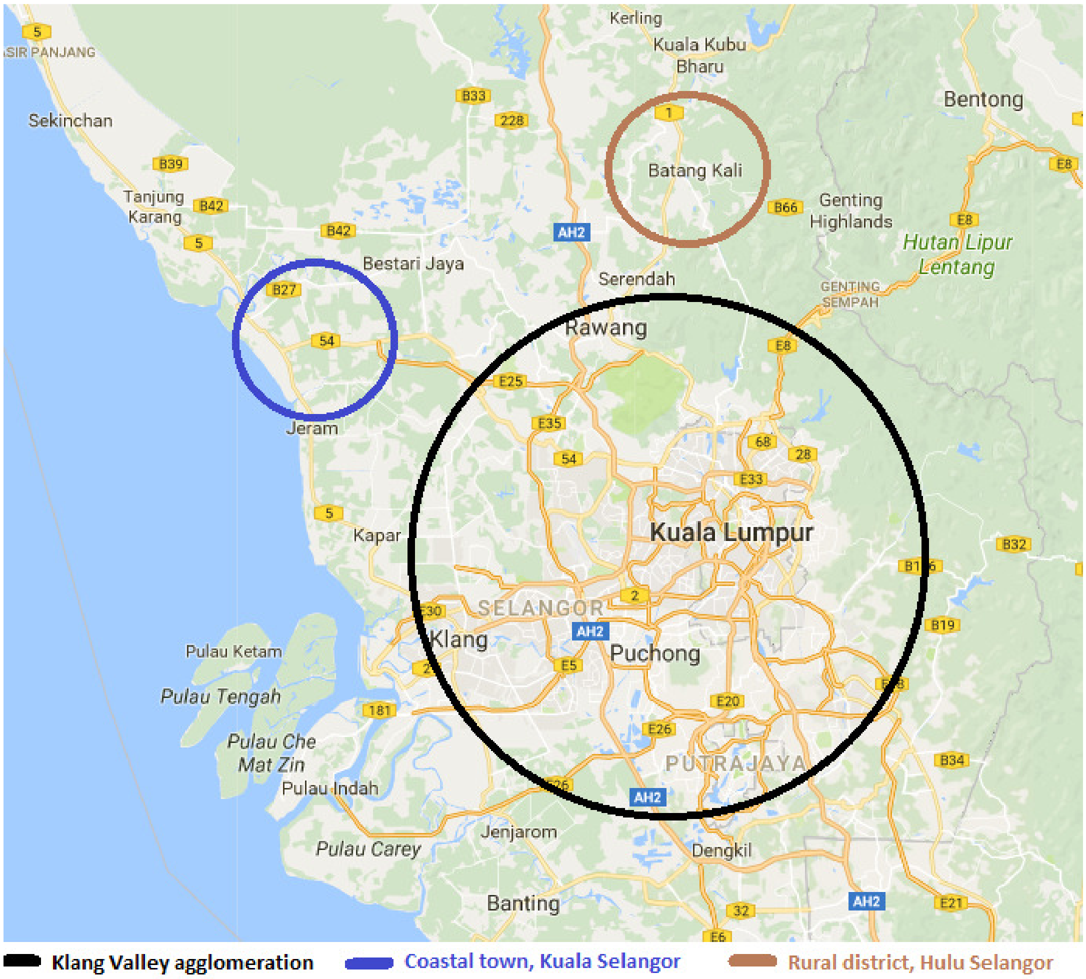
Malaysia is divided into two geographical regions: Peninsular Malaysia and East Malaysia. Peninsular Malaysia consists of eleven states and the capital city of Kuala Lumpur. East Malaysia is separated from the Peninsular by 640 km of the South China Sea, and includes the states of Sabah and Sarawak, situated on the island of Borneo (Figure 5). In 2016, total population of Malaysia is estimated at 31.7 million persons. Roughly 79% of the population is located in Peninsular Malaysia. Selangor recorded the highest percentage of population in 2016 (19.9%) followed by Sabah (12.0%) and Johor (11.5%) (DoSM, 2016).

Due to the size and diversity of Malaysia, it was difficult to carry out one survey that captures all of Malaysia. Based on logistical reasons and practicality, a decision was made to focus on the Klang Valley and Selangor. It may not be representative of the whole of Malaysia, but does have a good mixture of urban, rural and coastal samples across three major ethnic groups. Klang

Figure 5: Map of Malaysia (Source: Teh & Teh, 2014)

Valley, also known as the Greater Kuala Lumpur, is an area in Malaysia that is centred in Kuala Lumpur, and includes its adjoining cities and towns in the state of Selangor. The Klang Valley was chosen for urban samples in this study, given that it is the most densely populated region in Malaysia and is scattered with rural and coastal towns (Figure 6). Samples of the coastal population were collected in Kuala Selangor, a coastal town about 60 km away from central Kuala Lumpur (Figure 6). It has a total landmass of 1,194 km^2, a population of 205,257 and a population density of 170/km^2. The rural population were recruited in Hulu Selangor, a rural district about 50 km away from central Kuala Lumpur (Figure 6). It has a total landmass of 1,740 km^2, a population of 300,000 and a population density of 110/km^2. As the fish in these settings are mainly supplied by businesses from the Peninsular Malaysia, only the wholesalers and aquaculturists from the Peninsular Malaysia were recruited for survey study.

Figure 6: Location of data collection for consumer surveys (Google Maps, 2017)



2.6 ETHICAL CONSIDERATION

There are some fundamental ethical principles that researchers should consider of their research before commencing of research. The six key principles set out in the ESRC Framework for Research Ethics (2010) and their respective ways of implementation are discussed below:

i. *"Research should be designed, reviewed and undertaken to ensure integrity and quality."*

In order to ensure the quality and integrity of this research a number of ethical issues were taken into consideration over the lifecycle of the research design. These include the conduct and norms relating to the way background data and information about this research was gathered and presented; and the recruitment, participation and use of data generated from the research participants (Harwell, 2011). In this research, a number of measures were employed to address these ethical issues, including the independent desk study of relevant background literature without third-party assistance and the use of appropriate citations and referencing to avoid plagiarism and misrepresentation.

ii. "*Research staff and subjects must be informed fully about the purpose, methods and intended possible uses of the research, what their participation in the research entails and what risks, if any, are involved.* "

Research involving personal data received ethical approval from the University's research ethics committees (Appendix M). The researcher ensured that prior to taking part in the study, the aim and objectives of the research was explained to the participants as well as the scope of their involvement and the use of any subsequent data arising from their participation. The voluntary nature of participation and the option to withdraw from the study at any time were stated clearly to avoid coercion whilst recruiting potential participants. Potential participants were also assured of the confidentiality and anonymity of their responses. All participants gave a verbal consent stating their acceptance to take part in the different studies. Consent scripts were clearly articulated and were ensured to be understandable to subjects. The language used was non-technical (comparable to the language in a newspaper or general circulation magazine). Scientific, technical, and medical terms were defined or explained in lay terms. Statement indicating that participation is voluntary and that refusal to participate will not result in any consequences was also included.

iii. "*The confidentiality of information supplied by research subjects and the anonymity of respondents must be respected.*"

In order to maintain confidentiality of the personal identifiers collected from participants during the course of the study, these datasets were stored in accordance with the Malaysian Personal Data Protection Act 2010 and the UK Data Protection Act (1998). The data were stored in encrypted files separated from the body of the research data for duration of 2 years. The data will be deleted as soon as they are no longer required for logistic and administrative purposes. Additionally, generic identifiers such as names were replaced with alpha numeric codes to ensure that the research datasets are 'clean' and do not contain information that identifies any participants in the study. Copies of any information sheets given to participants are attached in the appendix.

iv. ***"Research participants must participate in a voluntary way, free from any coercion. "***

Participants' involvement in the research was assured to be truly voluntary. Informed Consent is the process through which researchers respect individual autonomy, the fundamental ethical principle. An autonomous individual is one who is capable of deliberation and personal choice. The principle of autonomy implies that responsibility must be given to the individual to make the decision to participate. Informed Consent means that subjects are well informed about the study, the potential risks and benefits of their participation and that it is research, not therapy, in which they will participate. Informed Consent is more than a form, it is also a process. Information must be presented to enable persons to voluntarily decide whether or not to participate as a research subject. The process of consenting was ongoing and was made clear to the subject that it is his or her right to "withdraw" or "optout" of the study at any time, not just at the initial of survey. The location where the consent was being discussed, the subject's physical, emotional and psychological capabilities were taken into consideration when consenting a human subject. The informed consent process ultimately assured that the subject understood what they were "signing up" for.

v. ***"Harm to research participants must be avoided."***

This research carries only negligible risk. There was no foreseeable risk of discomfort or harm as a result of participation in the research and if there was any foreseeable risk, it would not be of more than inconvenience (National Health and Medical Research Council, 2014). Examples of inconveniences involved were: filling in a form, participating in a street survey, giving up time to participate in research. To avoid possible emotional harm and risk of upset (although highly unlikely to happen), respondents were informed of their right to refuse to answer for any questions that were deemed sensitive. Respondents' anonymity was assured to dismiss their concerns about reputational damage (National Health and Medical Research Council, 2014) for being vocal during interviews and this was especially important for industrial respondents.

vi. "*The independence of research must be clear, and any conflicts of interest or partiality must be explicit.*"

It was explicitly declared in Chapter 1 that the researcher was funded by Crops For the Future (CFF). This form of researcher partiality had shaped the direction of the research through the generation of research problem. This thesis has set out to explore the research problem identified by CFF. However, to ensure that academic rigour was not compromised, an independent desk study of relevant background literature without third-party interference was conducted to identify knowledge gaps. The need to solve the research problem identified by CFF was justified. Other knowledge gaps that were relevant to the nature of the research problem were also adopted for investigation. Apart from the generation of research problem, the researcher remained independent and impartial throughout the subsequent research process.

2.7 THE LAYOUT OF THE THESIS

Since this study is interdisciplinary in nature and took an unconventional problem-oriented approach, the thesis was presented in a "project portfolio" format rather than the traditional format. Traditional thesis layout, although systematic, has lower comprehensibility and comprehensiveness of the research story when used to report interdisciplinary research. A "Project portfolio" thesis is more reader-focused as researchers are able to depict a coherent research story as the chapters unfold. The introductory chapter (Chapter 1) of a project-portfolio-based thesis is an over-arching, unifying introduction to the thesis as a whole. The introductory chapter contains information enabling a trained researcher reading the chapter to develop sufficient understanding of the field to understand the theme and hypotheses of the thesis. This current chapter (Chapter 2) contains methodologies that would enable a reader to understand the thinking process and how the research questions and methods came about. The processes followed to answer the respective research questions, with the selected methods (including the detailed procedures for each method) are presented in Chapters 3 to 6 (Table 5). Each of those chapters has an independent story to tell whilst being an integral part of the main storyline, hence it can be readily modified for publication. The concluding chapter (Chapter 7) draws together the discussion and conclusions relating to the third to sixth chapters of the thesis.

Table 5: The research questions behind each chapter

Chapter Number	Title	Research Question
Chapter 3	The Nutrition and Health Transition in Malaysia	R1, R2
Chapter 4	Malaysian Fish Consumption Habits and Its Sustainability	R1, R2
Chapter 5	Opportunity and Barriers to the Expansion of the Aquaculture Industry	R3
Chapter 6	Fish Purchasing Behaviours: Perception of Farmed Fish versus Scientific Evidence	R4, R5

CHAPTER 3: THE NUTRITION AND HEALTH TRANSITION IN MALAYSIA

3.1 INTRODUCTION

The epidemiological transition, particularly the rapid shift in morbidity and mortality patterns towards much higher noncommunicable disease rates, has dominated the health profile of an increasingly large number of people in higher income countries for the last half-century or more. Concurrent shifts in diet, activity and body composition also appear to be accelerating in many regions of the world (Popkin, 2015). Malaysia typifies a rapid developing country, which has undergone major demographic and socioeconomic changes since attaining independence in 1957. It is important to understand the transition pattern in Malaysia so that strategic intervention can be done to improve the health profile of the population. The enormous cost of the medical technology and tertiary health care needed for the diagnosis, treatment and management of these noncommunicable diseases will impose an undesirably huge burden on the human and economic resources of Malaysia.

This chapter focuses on the nutrition transition experienced in Malaysia during the last 30 – 40 years and points out some important distinguishing features. The main purpose of this paper is to provide an understanding of the multiple facets of nutrition transition, a sequence of characteristic dietary and nutritional patterns resulting from large shifts in the overall structure of diet, related to changing economic, social, demographic and health factors in Malaysia, one of the most rapidly modernised countries in ASEAN region.

3.2 METHODS

To describe the multidimensional phenomenon of nutrition transition in Malaysia, data were synthesised from multiple sources as detailed below in sections 3.2.1 and 3.2.2.

3.2.1 Demographic and Socio-economic Data

National demographics and socio-economic data were obtained from official spreadsheets and reports uploaded by the Department of Statistics, Malaysia on its open data portal: https://www.dosm.gov.my/v1/index.php?r=column3/accordionandmenu_id=aHhRYUpWS3B4VXlYaVBOeUF0WFpWUT09. These data included: (i) population growth rate, (ii) fertility rate, (iii) death rate and causes of death, (iv) under five mortality rate, (v) infant mortality rate, (vi) average life expectancy, (vii) old age dependency ratio, (viii) GDP index, (ix) quality of life index, (x) household income and expenditure, (xi) vehicle ownership rate, (xii) broadband penetration rate, and (xiii) poverty rate. The trends over time were then presented in sections 3.3.1, 3.3.2 and 3.3.8 accordingly.

3.2.2 Food and Health Data

To review Malaysian nutrition transition, data were gathered from three nationally representative sources, namely the Food Balance Sheets (FBS), Malaysian Adult Nutrition Survey (MANS) and National Health and Morbidity Survey (NHMS). A range of primary and secondary data from published reports and articles was used.

3.2.2.1 Food Balance Sheets (FBS) – 1980 to 2013

FAO defined a FBS as: "A comprehensive picture of the pattern of a country's food supply during a specified reference period, calculated from the annual production of food, changes in stocks, imports and exports, and distribution of food over various uses within the country" (FAO, 2001). From these data, the average per capita supply of energy and macronutrients can be derived for all commodities. These data refer to "average food available for consumption" and may not reflect actual per capita availability and consumption for a number of reasons e.g. plate waste and inequality in access to food. Another limitation is that the FAO statistical database (FAOSTAT) does not provide information on the distribution of food within community or households since it is based on national data.

Data for year 1980 onwards were downloaded from the FAOSTAT website (http://faostat.fao.org/site/368/default.aspx#ancor) in excel form (FAO, 2017a). The data for Malaysian FBS were available until 2013. The years were then grouped into several groups, with a range of five years for each group (i.e. 1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004, 2005-2009 and 2010-2013). Since the aim of this section is to determine the food trends in Malaysia for the past three decades, a trend of food supply would, therefore, be analysed. First, the estimation of total energy supply for the Malaysian population was analysed. This is measured in terms of calories (kcal/capita/day). The total energy is given by the grand total energy consumption of the total of vegetable and animal products. The FAO definition of vegetable products consist of the following: cereals, starchy roots, sugar crops, pulses, tree nuts, vegetable oil, vegetables, stimulants, spices, sugar and sweeteners, oil crops, fruits, alcoholic and miscellaneous; meanwhile, animal products consist of the following: meat, animal fats, eggs, milk (excluding butter), fish and seafood, aquatic product and offal (FAO, 2011).

The FBS analysis was the most widely used approach before Malaysia carried out the first MANS in 2003. Its biggest advantage is that it is accessible to anyone and is readily available online. However, the serious shortcoming of FBS is the classification of food. While all foods were divided into two groups, animal and vegetable supply, not all sub-groups underlying animal and vegetable food supply were relevant. For example, vegetable oil was classified as vegetal. Misinterpretation may occur if one assumes that vegetable food supplies only represent raw and fresh vegetables. FBS may be beneficial in showing basic trends of food supply, but is not useful to assess the present dietary intake of a population. FBS overestimated food consumption and nutrient intake compared to individual dietary surveys because FBS items were calculated excluding reuse and stock variation (national account budgets); they represented what food items were available per capita, but not obviously what was necessarily consumed.

3.2.2.2 Malaysian Adult Nutrition Survey (MANS) - 2003 and 2014

In Malaysia, nationwide dietary intake data was collected for the first time in MANS 2003 and then subsequently in 2014. MANS was a nationwide cross-sectional study conducted on more than 7000 subjects. Multistage stratified sampling design was used to select a representative sample of Malaysian adult population, aged 18 to 59 years old. Data on food consumption were derived from Food Frequency Questionnaire (FFQ) which contains 165 common consumed foods and beverages and one day 24-hour diet recall (Institute of Public Health, 2014). One primary (Institute of Public Health, 2014) and three secondary (Norimah et al., 2008; Mirnalini et al., 2008; Selamat et al., 2015) data analysis reports on MANS findings published on Institute of Public Health website and Malaysian Journal of Nutrition were obtained. The reports presented the energy contributions by macronutrients, dietary adequacy in relation to the Recommended Nutrient Intake for Malaysians, food consumption pattern and nutritional status via anthropometric nutritional assessment. In both MANS, about half of the population were under-reporters but were not excluded nor energy-adjusted, hence, cautious interpretation is needed.

3.2.2.3 National Health and Morbidity Survey (NHMS) I (1986) to V (2015)

The National Health and Morbidity Survey (NHMS) is a nationally representative survey of population of all levels in Malaysia, from new-borns to elderlies. It was first initiated in 1986 and has been an important platform for monitoring the health of the population in Malaysia. Its objectives were to supplement community-based data on the pattern of common health problems, health needs and expenditure on health in the community to enable the Ministry of Health to review priorities and activities of programmes, plan future allocation of resources and evaluate the impact of strategies. The interval of NHMS has been shortened from every 10 years to a 4 yearly cycle with annual data collection since 2011 to ensure timely information is obtained for planning of health programs. Time series data have restricted comparability due to the difference in body mass index (BMI) cut-off points and the study protocol. The main scopes in the NHMS since 2011 were health care demands, non- communicable diseases and non-communicable diseases risk factors. Primary data analysis reports for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) were available for download on the websites of Institute of Public Health (2017): http://www.iku.gov.my/index.php/research-eng/list-of-research-eng/iku-eng/nhms-eng. However, the primary data analysis reports for NHMS I (1986) and II (1996) were not publicly available; hence, references were made to a PowerPoint slides presented by Mr A.J. Ahmad, the Director Health Promotion Division of Ministry of Health Malaysia, at a health promotion conference in 2011.

3.3 RESULTS

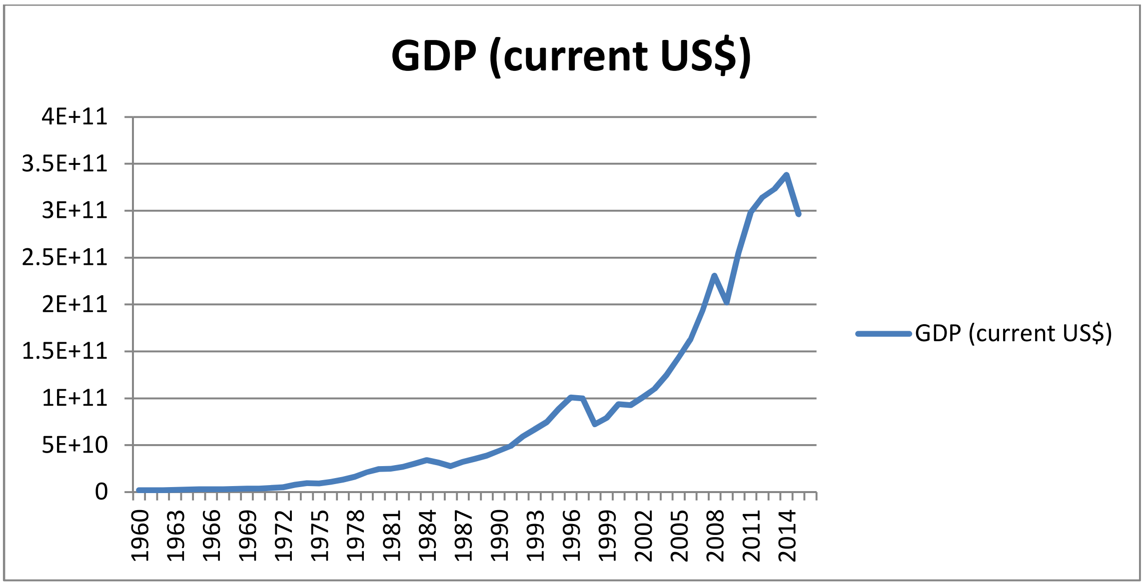
3.3.1 Demographic Transition

Comparison of the official statistics showed that population growth rate during the 1991 – 2000 period was on average at 3% per annum and then decreased to 1.8 % during 2000 – 2010. Demographic forecast estimated the population increase to be slow with the annual population growth rate decreasing to 0.8% by 2040, an average decrease of population growth rate by 0.05% per year. This slowdown of population growth is a reflection of reduction of fertility rate as the number has dropped from 6.19 births per woman in 1960 to 2.0 in 2015. The disparities were large among different ethnicities in Malaysia. Among the 3 major ethnic groups in Malaysia, the Malays recorded the highest growth rate (21.5%) during 2000-10 while the Chinese (12.3%) and Indians (13.6%) were very much lower for the same period. The pronounced slowdown in the growth rate of the Chinese and Indian population in Malaysia may be traced to their much lower fertility. Meanwhile, death rate of Malaysia fell gradually from 8.17 per 1,000 people in 1966 to 4.98 per 1,000 people in 2015. The reported under-five mortality rate has declined from 57 per 1000 live births in 1970 via 16.6 in 1990 to 8.1 in 2015. Similarly, the reported infant mortality rate has also declined from 41 per 1000 live births in 1970 via 13.0 in 1990 to 6 in 2015. Alongside with the reducing death rate, average life expectancy was on average 77.2 years for women and 72.6 years for men in 2016, up from 65.5 and 61.6 respectively for both genders in 1970. Malaysia is expected to experience the population ageing in 2020. An increase in the old age dependency ratio, almost a three-fold increase from 7.4 (2010) to 21.7 (2040), is expected.

3.3.2 Economic and Social Transition

Remarkable changes have occurred in the Malaysian economy and the structure of its workforce over the past 30 – 40 years. GDP per capita increased dramatically since the 1970s, achieving an average GDP growth rate of 6.8% per annum during the 1970-2015 periods (Figure 7). With this rapid shift in income, associated changes in the population and occupation distributions occurred. In 1960, the Malaysian population was approximately 27% urban and this increased to 75% urban by 2015. During the 1987 – 2014 periods, the economy has shifted from its initial dependence on energy intensive workforce, such as the rural primary-product sectors of agriculture, forestry and fisheries. In 2014, manufacturing and services accounted for 23% and 53.5% of GDP, respectively, while agriculture, forestry and fisheries accounted for 20% of GDP. On the other hand, education, health, housing and economic wellbeing have recorded the highest level of growth (>30%) of all the components of Quality of Life index, for the period of 1990 – 2007.

Figure 7: Malaysia GDP from 1960 to 2016 (Data adapted from https://www.dosm.gov.my/v1/index.php?r=column3/accordionandmenu_id=aHhRYUpWS3B4VXlYaVBOeUF0WFpWUT09 by the Department of Statistics, Malaysia)



The 2014 national mean gross household income was RM 6141 (US$ 1459.54*) monthly, with the bottom and middle 40% earning RM 2537 (US$ 602.76*) and RM 5662 (US$ 1345.21*) respectively, while the top 20% RM 14305 (US$ 3398.67*). There was significant income gap across different ethnicity and geographical locations. The income gap was wide between the urban (RM 6833 or US$ 1623.43*) and rural (RM 3831 or US$ 910.19*) as mean monthly gross income of the urban household was 78% higher than those of the rural. In 1970, mean monthly gross household income of the Chinese and Indians were 129% and 76% higher than those of the Malays. While disparities were still evident, the income gaps have improved to 38% and 12% respectively, in 2014, with the ethnic minorities Chinese (RM 7666 or US$ 1821.34*) and Indians (RM 6246 or US$ 1483.96*) earning above the national mean while the ethnic majority Malays (RM 5548 or US$ 1318.13*) were behind the national mean. The annual growth of mean household income was about 11% in the 1990s and 9% annually since the 2000s up to 2014. In tandem with improvements in household incomes, vehicle ownership across all types increased, with the percentage of

*approximate US$ equivalent as of 26th September 2017

Malaysian households owning cars as high as 83.9% in 2014 and the broadband penetration rate in the second quarter of 2015 stood at 72.2%.

According to official statistics, the overall poverty rate reduced by more than half from 1.7% to 0.6% between 2012 and 2014, and hardcore poverty were almost eradicated. However, it might be too early to proclaim "significant achievement in poverty eradication" because the current practice of measuring poverty based solely on the Poverty Line Income (PLI). Although the poverty rate was 0.6%, 11.7% of households earn less than RM2000 (US$ 475.17*) and were therefore vulnerable to shocks. By considering multiple facets of well-being beyond income, the 11th Malaysia Plan 2016 – 2020, launched in 2015, introduced a Multidimensional Poverty Index (MPI), which broadens the definition of poverty to not only include income, but also vulnerabilities in health, living standards, and education attainment (EPU, 2015). The MPI serves as the complementary index to the PLI in identifying the pockets of poverty in Malaysia (EPU, 2015). However, the 11th Malaysia Plan did not publish the poverty rate estimated with MPI. On top of that, there were still some pockets of poverty. According to the 11th Malaysia Plan, the poverty rate for indigenous people ("*Orang Asli"*) in Peninsular Malaysia remained high at 34%, and at 20.2% and 7.3%, respectively, in Sabah and Sarawak.

On top of that, the household expenditure survey did not take into account instalment payments on loans, including those for housing and automobiles. The lower income households are assumedly the most financially insecure. Predictably, the existence of these different economic classes will be reflected in the coexistence of under- and overnutrition. The acceleration of urbanisation contributes to uneven distribution of development benefits between urban areas and urban-rural areas which creates some degree of regional imbalances. Urban poverty is a dynamic condition of vulnerability due to rapid urbanisation (Abd Aziz et al., 2011). In other words, rapid pace of urbanisation increases the vulnerability of the urban dwellers. Yusoff el al (2013) identified the vulnerable groups in urban areas of the country as low and moderate income people (whose monthly income was, on average, MYR 2334 or US$ 554.86*), single parent and people with low educational level and engaged in low skill and less productive sector. The number of urban vulnerable people was high in more developed states of the country such as Selangor and Johor (Siwar et al., 2016).

*approximate US$ equivalent as of 26th September 2017

3.3.3 Food Consumption Changes

A review into FBS data series that run from 1980 to 2014 has shown that the total energy supply (kcal/capita/day) for the Malaysian population remained in excess of average calories needs, i.e. 1500 kcal for an average woman and 2000 kcal for an average man (Ministry of Health Malaysia, 2017). The total energy per caput supply was stable over time with just a slight increase of about 5% over the last three decades (Table 6). However, there were rather significant signs of shifting trends, particularly in the supply of wheat, rice, sugar and sweeteners, meat, fish and seafood, milk and eggs. Rice supply fell by 23.7% while the supply of wheat rose by 56.5% (Table 6). The per caput total sugar and sweetener supply for Malaysia has increased by 23.9% over the past 3 decades (Table 6). The per caput total supply of animal products too increased (meat by 49.3%; fish and seafood by 38.7%; egg by 55.7%) except for milk (fell by 30%) (Table 6). Meanwhile, the total supply of vegetable products was not much different over the same period of time comparatively (Table 6). When the per caput calorific contribution was expressed as the percentage of grand total energy supply, it was obvious that the importance of wheat (and products), sugar and sweeteners and animal products were growing at the expense of rice intake over the course of 30 odd years since the 80s (Figure 8 and 9). Increasing supply of wheat and animal products while slowly diverging away from the traditional staple of rice is the greatest consequence of globalisation and reflects the westernisation of the diet (Pingali, 2007).

Table 6: Daily per caput dietary energy supply (kcals) by products over the 34-year period

(Source: Adapted from FAO, 2017a)

Year	Grand Total	Cereals - Excluding Beer	Wheat and products	Rice (Milled Equivalent)	Sugar and Sweeteners	Vegetable Oils	Meat and Offal	Fish and Fish Products	Milk - Excluding Butter	Eggs
80-84	2758.0	1295.0	249.6	999.4	326.8	404.8	184.2	78.4	102.2	37.4
85-89	2638.2 (-4.3%)	1081.8 (-16.4%)	246.6 (-1.2%)	785.2 (-21.4%)	343.6 (+5.1%)	443.8 (+9.6%)	207.4 (+12.6%)	78.8 (+0.5%)	97.8 (-4.3%)	42.0 (+12.3%)
90-94	2739.4 (+3.8%)	1158.0 (+7.0%)	269.6 (+9.3%)	826.8 (+5.3%)	374.6 (+9.0%)	355.8 (-19.8%)	272.9 (+31.6%)	86.0 (+9.1%)	107.8 (+10.2%)	51.2 (+21.9%)
95-99	2909.2 (+6.2%)	1251.2 (+8.0%)	289.2 (+7.3%)	848.6 (+2.6%)	469.2 (+25.3%)	332.6 (-6.5%)	281.1 (+3.0%)	103.0 (+19.8%)	107.8 0%	50.6 (-1.2%)
00-04	2811.2 (-3.4%)	1255.4 (+0.3%)	346.6 (+19.8%)	752.8 (-11.3%)	381.2 (-18.8%)	373.8 (+12.4%)	242.7 (-13.7%)	108.0 (+4.9%)	107.6 (-0.2%)	46.0 (-9.1%)
05-09	2813.0 (+0.1%)	1295.8 (+3.2%)	422.0 (+21.8%)	753.0 (0.0%)	360.8 (-5.4%)	363.2 (-2.8%)	256.1 (+5.5%)	107.0 (-0.9%)	84.2 (-21.7%)	47.6 (+3.5%)
10-13	2895.5 (+2.9%)	1271.0 (-1.9%)	390.8 (-7.4%)	762.8 (+1.3%)	404.8 (+12.2%)	391.5 (+7.8%)	275.1 (+7.4%)	108.8 (+1.6%)	71.5 (-15.1%)	58.3 (+22.4%)
Nett Change	**+5.0%**	**-1.9%**	**+56.6%**	**-23.7%**	**+23.9%**	**-3.3%**	**+49.3%**	**+38.7%**	**-30.0%**	**+55.7%**

* The change from one 5-year block to another is expressed as percentage in bracket

* Nett change equals the change in value divided by the absolute value (for 2010-2013) of the original value (for 1980-1984), multiplied by 100

Figure 8: Average percentage of contribution of daily per caput dietary energy supply (kcals) by products based on FBS 1980-1984
(Source: Adapted from FAO, 2017a)

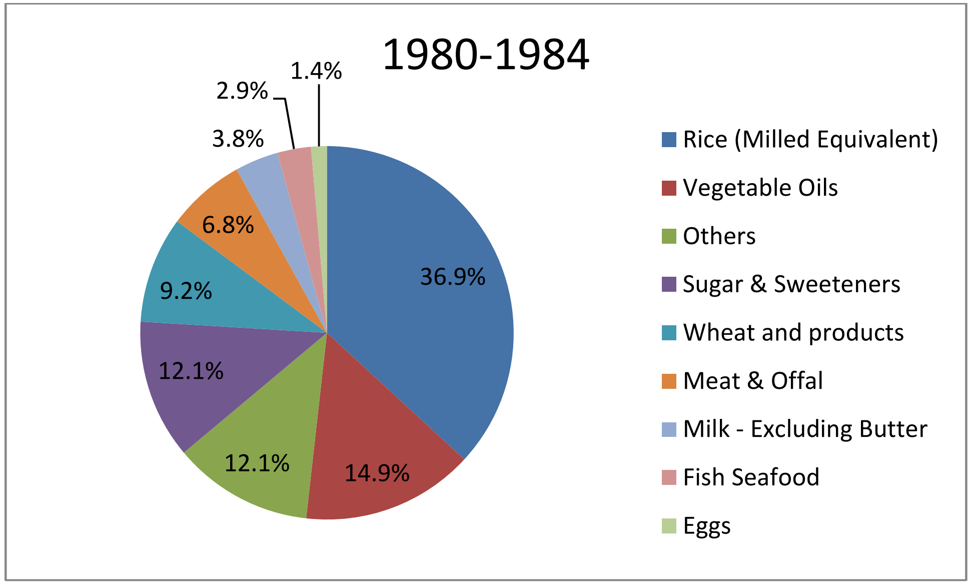


Figure 9: Average percentage of contribution of daily per caput dietary energy supply (kcals) supply by products based on FBS 2010-2013
(Source: Adapted from FAO, 2017a)

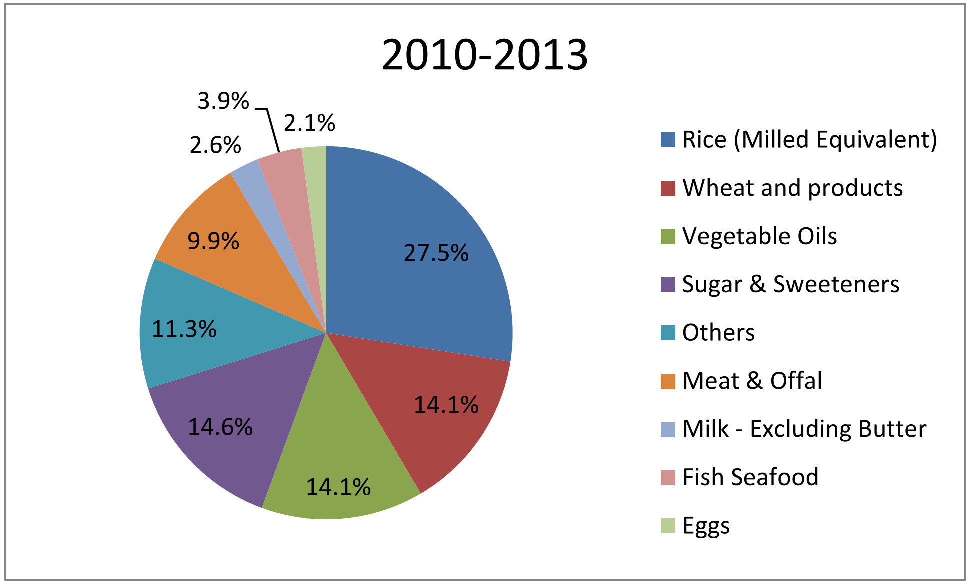


Figure 10: Average percentage of contribution of daily per caput protein supply (g) by animal products based on FBS 1980 – 1984 (Source: Adapted from FAO, 2017a)

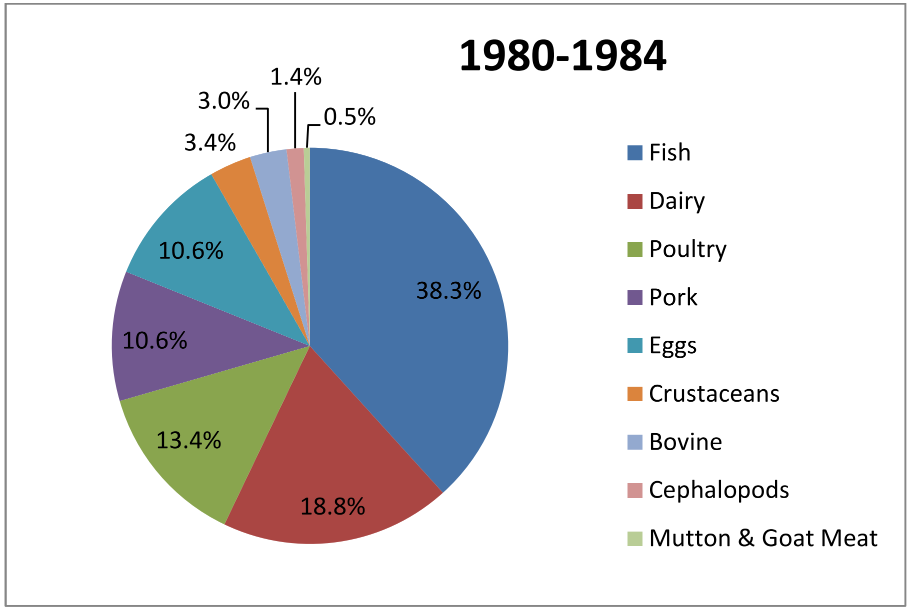
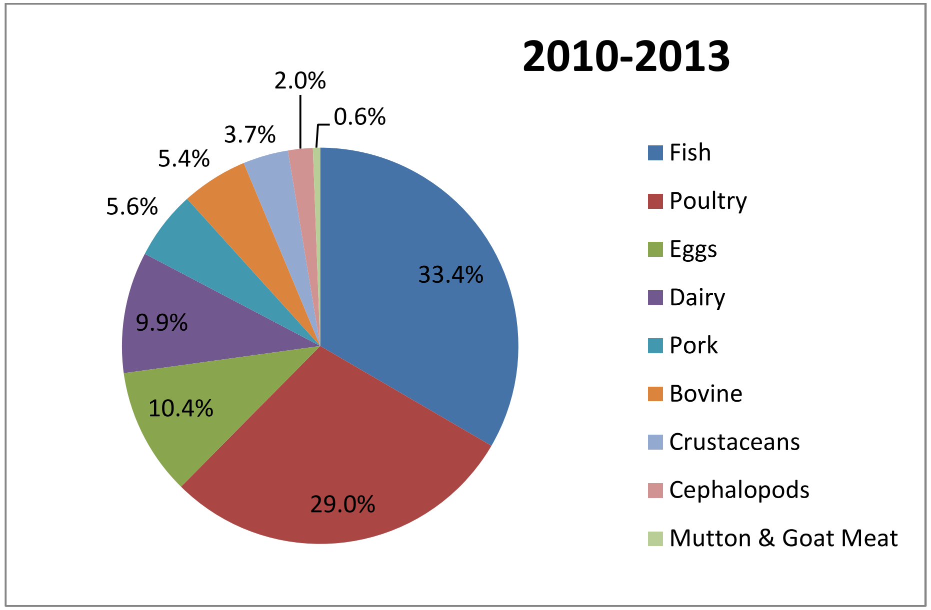


Figure 11: Average percentage of contribution of daily per caput protein supply (g) by animal products based on FBS 2010 – 2013 (Source: Adapted from FAO, 2017a)



Comparison of FBS during the period of 1980 – 2013 shown that the overall per caput protein supply increased by 33.8% (Table 7) during the said period. The plant to animal protein ratio has decreased over time. The total protein from animal products supply has seen a 59.1% of increment and has gradually exceeded protein supply from vegetable products. This trend of increment, however, is not uniform across the subcategories of animal products (Table 7). While fish remain the biggest contributor of per caput protein supply, the importance of poultry has risen at the expense of dairy. Poultry emerged as the second biggest contributor in 2010-2013, rose from 13.4% in 1980-1984 to 29.0% on 2020-2013 while dairy declined from 18.8% to 9.9% (Figure 10 and 11). Other less popular animal protein sources have seen fairly small marginal increase (Figure 10 and 11). Vegetal source remained as the dominant source (65%) of per caput fat supply (Table 8). However, the per caput fat supply of animal products has increased by 25.6% which reflects the aforementioned increment of per caput energy supply of animal products (Table 8).

Table 7: Daily per caput supply of animal and vegetal products in terms of protein over the 34-year period
(Source: Adapted from FAO, 2017a)

g/capita/day	Grand Total (Protein)	Vegetal Products (Protein)	Animal Products (Protein)
80-84	60.0	32.2	27.8
85-89	59.4 (-1.0%)	28.5 (-11.5%)	30.9 (+11.0%)
90-94	69.1 (+16.3%)	30.5 (+7.0%)	38.6 (+24.8%)
95-99	76.2 (+10.3%)	33.0 (+8.2%)	43.2 (+11.9%)
00-04	76.2 (0.0%)	34.1 (+3.3%)	42.1 (-2.6%)
05-09	78.4 (+2.9%)	36.1 (+5.9%)	42.2 (+0.4%)
10-13	80.3 (+2.5%)	36.0 (+-0.3%)	44.3 (+4.9%)
Nett Change	+33.8%	+11.9%	+59.1%

* The change from one 5-year block to another is expressed as percentage in bracket

* Nett change equals the change in value divided by the absolute value (for 2010-2013) of the original value (for 1980-1984), multiplied by 100

Table 8: Daily per caput supply of animal and vegetal products in terms of fats over the 34-year period
(Source: Adapted from FAO, 2017a)

g/capita/day	Grand Total (Fat)	Animal Products (Fats)	Vegetal Products (Fats)
80-84	84.9	26.3	58.5
85-89	90.1 (+6.2%)	27.6 (+4.8%)	62.5 (+6.8%)
90-94	87.5 (-2.9%)	34.1 (+23.6%)	53.3 (-14.6%)
95-99	85.6 (-2.1%)	34.8 (+1.9%)	50.8 (-4.7%)
00-04	86.4 (+0.9%)	30.8 (-11.5%)	55.6 (+9.5%)
05-09	84.2 (-2. 6%)	31.1 (+1.2%)	53.1 (-4.6%)
10-13	88.8 (+5.5%)	33.1 (+6.3%)	55.7 (+5.0%)
Nett Change	+4.6%	+25.6%	-4.8%

* The change from one 5-year block to another is expressed as percentage in bracket

* Nett change equals the change in value divided by the absolute value (for 2010-2013) of the original value (for 1980-1984), multiplied by 100

White rice continued to be a staple food of the Malaysian population and fish remained as the most popular animal protein source. According to MANS 2014 report, cooked rice was the top food consumed daily by adults in Malaysia (89.8%), with an average of 2½ plates per day and about 70% of adults consumed at least 1 serving of fish a day. The prevalences of other top food items consumed daily were sugar (55.9%), followed by leafy green vegetables (43.2%) and chillies (24.2%). In MANS 2014 study, adults from rural areas consumed significantly more cooked rice daily while those from urban areas consumed significantly more sugar and marine fish daily. Meanwhile, men consumed significantly higher amounts of cooked rice and sugar daily as compared to women. About 98.2% adults in MANS 2014 consumed plain water daily with an average 8 glasses per day, whereas 98.6% of them were reported to consume sugar sweetened beverages (SSB) of mean intakes of 2 glasses daily. The top five SSB consumed in MANS 2014 was tea (70.3%), followed by malted drink (59.1%), coffee (53.2%), soy milk (51.4%) and carbonated drink (45.6%). Overall, there was almost similar habitual food items reported in both 2003 and 2014 MANS reports, but an increased consumption of "processed foods" such as soy sauce and condiments was observed. There was also an increasing popularity of sugar and sugar-based food consumption among adults as the consumption of sugar and sugar based foods contributed to at least 4 food items in a day (≈ 6.5

times/ day). MANS 2003 estimated that 55.2% of total protein consumed derived from animal source but such information was not available from MANS 2014 report. Alarmingly, NHMS 2011 recorded that 92.5% of adults 18 years and above consumed less than 5 servings of fruits and/or vegetables per day. The figure has worsened to 94% in NHMS 2015.

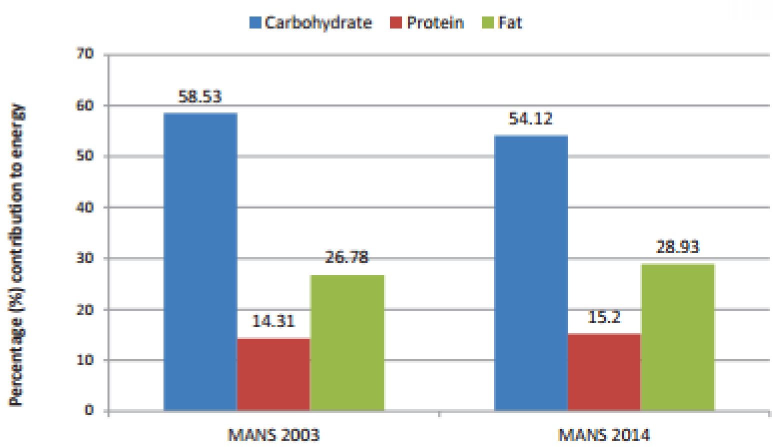
3.3.4 Household Food Insecurity in Malaysia

Findings from MANS 2014 showed that lower-income households, which spent proportionately more of their income on food compared to those with higher incomes, were less able to afford nutritious food. The prevalence of Malaysian adults that had both reduced the size of meals and skipped main meals because of financial constraints at least one or two months in the past 12 months was 13.4%. This prevalence was significantly higher in East Malaysia (20.3%) than in Peninsular Malaysia (11.5%) and in rural areas (18.8%) than in urban areas (11.0%). It was also highest among households with income <RM3000 or US$ 712.76* (19.1%) and no formal education (45.8%) whereas lowest among household income RM 6000 or US$ 1425.52* (2.1%) and tertiary education (6.0%). The prevalence of households that both relied on cheap foods and could not afford to feed their children with food variety because of financial constraints was 18.9%. It was significantly higher in East Malaysia (34.5%) than in Peninsular Malaysia (14.8%).

3.3.5 Changes in Nutrient Intake

Figure 12: Percentage contribution of macronutrients

to daily energy intake in MANS 2003 and 2014 (Institute of Public Health, 2014)



MANS 2014 recorded that Malaysian adults, on average, had an energy intake (1466 kcal/day) that met only 64% of RNI which is 6% lower compared to MANS 2003 (Figure 12). These figures did not reflect the surge of overweight epidemic in Malaysia as presented in Section 3.3.6. The mean carbohydrate intake of Malaysian adults was approximately 54% of the total energy intake. Malaysian adults recorded a mean protein and fat intake of about 15% and 29% of total energy intake. The macronutrient ratios were similar in both 2003 and 2014 studies, albeit in 2014 there was a marginal increment of the percentage contribution of protein and fat to daily energy intake at the expense of carbohydrate. However, about half of the adults in MANS 2014 were found to have exceeded the recommended protein contribution to total energy intake (50.7%) and fat contribution intake to total energy intake (45.6%) according to RNI. In terms of micronutrients adequacy, both 2003 and 2014 MANS reported that about half of the population were below the RNI for calcium, thiamine, iron vitamin A and vitamin C. Slightly less than half of the adult population were below the RNI for iron and vitamin A. With lower reported energy intake, the intake of many micro-nutrients was expected to decrease. These data need to be treated with caution as it was pointed out in the report that there was a high percentage of under reporting during dietary recall, limitation in food composition database and human error during data management and analysis.

3.3.6 Prevalence of Selected NCD and NCD Risk Factors

There was an increasing trend of overweight among Malaysians from 1996 to 2014 but the prevalence rates have seemingly remained fairly constant from 2011 to 2015 (Table 9). In 2006, prevalence of obesity among adults was 14.0%, a relative increase of over 200% from that of 10 years earlier (Table 9). CPG (2004) classification was adopted in NHMS since year 2011 because Malaysians are at a higher risk of obesity-related morbidity and mortality as Asians tend to have higher amounts of abdominal fat at lower BMIs (WHO, 2000). The reduction of threshold level could have increased the magnitude of prevalence but was not formally discussed in the respective NHMS reports. Using the new classification, about two-third of the adult population was overweight or obese in 2015 (Table 9).

Table 9: The prevalence of selected risk factors of NCD in adults of 18 years and above (Source: data for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) from Institute of Public Health (2017), for NHMS I (1986) and II (1996) from Ahmad (2011), and for MANS (2003) and MANS (2014) from Institute of Public Health (2014)

	NHMSII (1996)	**MANS (2003)**	**NHMSIII (2006)**	**NHMS IV (2011)**	**MANS (2014)**	**NHMS V (2015)**
Age group	**≥18 yrs**	**≥18 yrs**	**≥18 yrs**	**≥ 18 yrs**	**≥18 yrs**	**≥ 18 yrs**
Physically inactive	88.4%*	NA	43.7%	35.2%	NA	33.5%
Overweight	16.6%[a]	26.7%[a]	29.1%[a]	33.3%[b]	32.4%[a]	33.4%[b]
Obese	4.4%[a]	12.2%[a]	14.0%[a]	27.2%[b]	18.5%[a]	30.6%[b]

* Previous data cannot be compared as methodology differed between surveys

[a] According to WHO classification, overweight is defined as BMI ⩾ 25kg/m^2 and <30kg/m^2 and obesity as BMI ⩾ 30kg/m^2.

[b] According to CPG (2004) classification, overweight is defined as BMI ⩾ 23.0 kg/m^2 and < 27.4 kg/m^2 and obesity as BMI ⩾ 27.5 kg/m^2.

3.3.6.1 Prevalence of Diabetes

Overall, comparison of NHMS statistics from various years shown that diabetes was becoming more prevalent and that an increasing trend in newly diagnosed cases was evident (Table 10 and 11). The increasing trend was more alarming among adults 30 years and above. The prevalence of diabetes is 22.5 % in 2015, a relative increase of 170% from about two decades earlier (8.3%) (Table 11).

Table 10: Prevalence of diabetes 18 years old and above (Source: data for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) from Institute of Public Health (2017)

	NHMS III (2006)	**NHMS IV (2011)**	**NHMS V (2015)**
Age group	**≥ 18 yrs**	**≥ 18 yrs**	**≥ 18 yrs**
Prevalence	11.6%	15.2%	17.5%
Known diabetes	7.0%	7.2%	8.3%
Newly diagnosed	4.5%	8.0%	9.2%

Table11: Prevalence of diabetes 30 years old and above (Source: data for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) from Institute of Public Health (2017) and for NHMS I (1986) and II (1996) from Ahmad (2011)

	NHMS I (1986)	**NHMS II (1996)**	**NHMS III (2006)**	**NHMS IV (2011)**	**NHMS V (2015)**
Age group	**≥ 35 yrs**	**≥ 30 yrs**	**≥ 30 yrs**	**≥ 30 yrs**	**≥ 30 yrs**
Prevalence	6.3%	8.3%	14.9%	20.8%	22.5%
Known diabetes	4.5%	6.5%	9.5%	10.7%	11.9%
Newly diagnosed	1.8%	1.8%	5.4%	10.1%	10.6%

3.3.6.2 Prevalence of Hypertension

Data from various NHMS shown that the prevalence of hypertension increased one-fold from 1986 to 1996 and has remained fairly constant since then at about one-third of the adults above 18 years old (Table 12 and 13). Even higher prevalence rates were seen among adults above 30 years old.

Table 12: Prevalence of hypertension 18 years old and above (Source: data for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) from Institute of Public Health (2017), and for NHMS I (1986) and II (1996) from Ahmad (2011)

	NHMS I (1986)	**NHMS II (1996)**	**NHMS III (2006)**	**NHMS IV (2011)**	**NHMS V (2015)**
Age group	**≥25 yrs**	**≥18 yrs**	**≥18 yrs**	**≥ 18 yrs**	**≥ 18 yrs**
Prevalence	14.4%	29.9%	32.2%	32.7%	30.3%

Table 13: Prevalence of hypertension 30 years old and above (Source: data for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) from Institute of Public Health (2017), and for NHMS II (1996) from Ahmad (2011)

	NHMS II (1996)	**NHMS III (2006)**	**NHMS IV (2011)**	**NHMS V (2015)**
Age group	**≥30 yrs**	**≥30 yrs**	**≥30 yrs**	**≥30 yrs**
Prevalence	32.9%	42.6%	43.5%	39.8%

3.3.6.3 Hypercholesterolemia

As seen in the findings of NHMS from previous years, the prevalence of hypercholesterolaemia was high and is on the increasing trend (Table 14 and 15). About half of the adult population had high blood cholesterol and the prevalence was higher in older adults. Prevalence among adults ≥30 yrs and above had increased more than fourfold from 11.7% in 1996 to 56.8% in 2015 (Table 15).

Table 14: Prevalence of hypercholesterolemia 18 years old and above (Source: data for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) from Institute of Public Health (2017), and for NHMS II (1996) from Ahmad (2011)

	NHMSII (1996)	**NHMSIII (2006)**	**NHMS IV (2011)**	**NHMS V (2015)**
Age group	**≥18 yrs**	**≥18 yrs**	**≥ 18 yrs**	**≥ 18 yrs**
Hypercholesterolaemia	NA	20.6%	35.1%	47.7%

Table 15: Prevalence of hypercholesterolemia 30 years old and above (Source: data for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) from Institute of Public Health (2017), and for NHMS II (1996) from Ahmad (2011)

	NHMS II (1996)	**NHMS III (2006)**	**NHMS IV (2011)**	**NHMS V (2015)**
Age group	**≥30 yrs**	**≥30 yrs**	**≥30 yrs**	**≥30 yrs**
Prevalence	11.7%	28.2%	43.9%	56.8%

3.3.7 Malnutrition

In Malaysia, despite rapid economic growth and development and improvements in socio-economic status and health care system, child under-nutrition still persists. The prevalences of underweight and stunting among children aged below 18 years were 13.2 % and 17.2 % in NHMS 2006, while in NHMS 2011, 16.1 % and 13.4 % of the children were found to be underweight and stunted respectively. In NHMS 2015, the prevalences of underweight and stunting among Malaysian children were 13.0 % and 13.4 % respectively. At the same time, childhood obesity was also increasing in Malaysia. The prevalence of obesity among Malaysian children below 18 years old has increased from 6.1 % in NHMS 2011 to 11.9 % in NHMS 2015. In another nationwide survey, SEANUTS Malaysia, funded by private company on nutritional status of children aged 6 months to 12 years, the overall prevalences of overweight and obesity among the children were 9.8 % and 11.8 % respectively (Poh et al., 2013). On the other hand, the prevalence of underweight among adults above 18 years old has fallen to 6.2% in NHMS 2015 from 25.2% previously reported in NHMS 1996.

3.3.8 Causes of Death

Malaysia is undergoing an epidemiological transition with causes of mortality shifting from communicable to non-communicable diseases. Comparison of national statistics has shown that most deaths in Malaysia now were from non-communicable diseases, with diseases of the circulatory system (heart and lungs) the most common cause of death (Table 16). Malaysia differs from high-income countries in its higher mortality rates from infectious diseases and road accidents (Table 16). Malaysia needs better mortality data since some deaths are not medically certified and not all coders use International Classification of Diseases (ICD) codes (WHO, 2012).

Table 16: Five major causes of mortality, 1995 – 2014 (Source: Adapted from https://www.dosm.gov.my/v1/index.php?r=column3/accordionandmenu_id=aHhRYUpWS3B4VXlYaVBOeUF0WFpWUT09 by the Department of Statistics, Malaysia.)

1995		2000		2005		2008		2014	
Cause	**%**	**Cause**	**%**	**Cause**	**%**	**Cause**	**%**	**Cause**	**%**
Heart and pulmonary circulation diseases	16	Heart and pulmonary circulation diseases	15	Septicaemia	17	Heart and pulmonary circulation diseases	17	Ischaemic heart diseases	14
Accidents	10	Septicaemia	14	Heart and pulmonary circulation diseases	14	Septicaemia	13	Pneumonia	12
Cerebrovascular diseases	10	Malignant neoplasms	9	Malignant neoplasms	10	Malignant neoplasms	11	Cerebrovascular diseases	7
Septicaemia	10	Cerebrovascular diseases	9	Cerebrovascular diseases	8	Pneumonia	9	Septicaemia	6
Malignant neoplasms	9	Accidents	8	Accidents	6	Cerebrovascular diseases	9	Accidents	6

3.4 DISCUSSION

The nutrition transition in Malaysia over the past three decades as reviewed earlier is one facet of a more general demographic, nutritional and epidemiological transition that accompanies development and urbanisation. The nutritional situation in Malaysia is characterised by the coexistence of both under- and overnutrition with different stages of declining undernutrition and increasing overnutrition. This situation clearly indicates a failure in providing the right foods to those who need it when they need it. While Malaysia experienced a large reduction in the incidence of poverty during the last few decades due to the booming of Malaysian economy, poverty still remains a major challenge in the development of the country (Othman and Kari, 2008; Nair, 2010). Excessive urban growth leads to escalating economic and social costs, which could lead to deterioration of the living standard of the Malaysian urban population and consequently incidence of poverty and food insecurity (Siwar et al., 2016). When costs of living increase, consumers tend to eat more cheap staple foods while cutting their intake of nonstaple foods that tend to be richer in micronutrients (Bouis et al., 2011). The empty calories of many staple foods disguise a “hidden hunger” that affects the health and wellbeing of its bearer.

The epidemiological transition in Malaysia is reflected in a growing burden of non-communicable diseases. Current review found that there was a shift from nutrient deficiency and infectious diseases characterising poor populations to the problem of coexistence of the latter with non-communicable disease (NCD) that were in the past characteristic of developed countries. In fact, the NCD and its risk factors are now emerging as a major health problem in Malaysia. One of the leading risk factors for NCD is obesity caused by the nutrition transition. Passing from a rural to an urban lifestyle is marked by changes in dietary habits and physical activity patterns. High ownership of a car and television in Malaysia could be related to sedentary work and being sedentary during leisure time. On top of that, the population’s diet has shifted towards increased sugar based food, high sodium processed food and animal fat, but lower fruits and vegetable consumption. These dietary changes coupled with sedentarism are associated with health consequences leading to high prevalence of CVD risk factors and NCD. The alarming prevalence of risk factors among Malaysian adult population deserves immediate attention and effective intervention.

Because of the progress in healthcare, the population development was found to be characterised by a significant decrease in child mortality, a relatively slow onset of fertility and increasing life expectancy. The Malaysian population is ageing and this will have a major impact on the strategies required to meet the future food and nutrient needs. Past effort mainly focused on prevention or treatment of undernutrition especially among children. As the proportion of under 18 years age group reduces, the health and nutrition infrastructure will therefore not have to cope with the ever-increasing numbers of children needing health and nutrition care, thus leaving it more capacity to concentrate on the quality and coverage of health and nutrition services needed to improve health and nutritional status of the working age groups (FAO, 2006). If their health and nutrition needs are met, massive improvement in nutrition and health status can be made (FAO, 2006). On top of that, appropriate counselling will enable the working age groups to adopt life styles and diets that prevent the escalation of overnutrition and the attendant non-communicable disease risk in their later years of life (FAO, 2006). For the increasing number of seniors over 60 years old, provisions for managing their nutritional and health problems would have to be made (FAO, 2006).

However, this should not hinder the efforts to reduce the continuing existence of undernutrition, especially among children. Interventions aimed at improving the nutritional status of local population should inevitably address both facets of malnutrition – undernutrition and overweight – through the improvement and modification of diet and lifestyle. Nonetheless, traditional poverty alleviation and food programs can have unforeseen consequences, especially in environments where activity patterns have shifted toward more sedentary activity (Popkin et al., 2012). As seen in studies in Chile and Mexico (Uauy and Kain, 2002; Fernald et al., 2008), there is the possibility that current feeding programs that aim to reduce hunger and malnutrition may cause increased weight gain and obesity; instead of focusing on providing additional calories, their target populations may need more nutrient-dense foods. Food insecurity is complex and multifaceted, and the paradox is that not only can it lead to undernutrition and persistent hunger, but also to overnutrition, which can lead to overweight and obesity (Tanumihardjo et al., 2007).

On top of that, governmental policy and interventions ought to focus on reducing the population's calorie intake through improving the healthiness of food systems and environments. To maintain healthy weight in local populations, food consumption is equivalent to the energy requirement; food consumption above or below the energy requirement results in nutritional imbalance (Valin et al., 2014). The difference between the food availability and the energy requirement of a local population can be used as a gauge to estimate food surplus at the consumer level (Hall et al., 2009). Overabundance was found to be the contributing factor to obesity epidemic, according to a new study from the World Health Organisation (WHO) (Vandevijvere et al., 2015). It was found in their study that the increase in the amount of per-capita food energy available to people in 56 countries has created excesses that alone can account for increases in average body weight; the increase of food availability and food energy supplies led to a food energy consumption greater than the needs. While the low reported energy intakes found in MANS were unreliable, the ever-increasing prevalence of obesity and constant per caput food energy supply surplus in Malaysia were consistent with the findings of Vandevijvere et al. (2015). Malaysia is also becoming increasingly obesogenic as food is plentiful, cheap and made more easily available in Malaysia round-the-clock from fast food joints, night markets, hawker stalls and 24-hour eateries.

Apart from increasing healthcare burden, food surplus also imposes climate burden. The agricultural sector contributes to around 22 to 24 percent of the total anthropogenic greenhouse gas (GHG) emissions and 56 percent of the total non-CO_2 GHG emissions (Smith, 2014). Current FBS review also found that there was a surge of supply in animal products and refined and processed food, of which both are produced via intensive production system that would further contribute to the worsening climate inequity. Meat-based food system, for instance, requires more energy, land, and water resources than vegetarian or even the lacto-ovo-vegetarian diet (Pimentel and Pimentel, 2003); hence, the rising supply of animal protein sparks doubts about sustainability. Increasing population coupled with rapid urbanisation and industrialisation means the amount of agricultural land available per person will shrink in the future. Destruction of important ecosystems will have dramatic feedback effects that threaten the sustainability of our food systems, which eventually will create more insecurities and conflict. Resource scarcities pose an unquantifiable risk for food security. The uncertainties are mainly associated to unpredictable changes in climate and biodiversity relations as climate change and biodiversity loss exacerbate each other in multifarious ways.

Take fish for example; the ever-increasing supply and demand of this traditional staple and the biggest animal protein source in Malaysia can result in overfishing when more fish are caught than the population can replace through natural reproduction. Climate change and unsustainable fishing method will lead to die-back of coral reefs and destruction of coastal ecosystems that may be even more catastrophic to future food security and sustainability. As such, unreasonable increase in demand for food that is more resource-intensive to produce needs to be mitigated through multidimensional interventions. A more sustainable food production and adjusted consumption would have favourable environmental effects (Hiç et al., 2016). Aquaculture, for instance, has been actively promoted in Malaysia as a means to relieve the burden on wild fish stocks but its sustainability still remains a question. On the other hand, little detail is known about the role of fish in Malaysian diet, hence making it not possible to establish guidelines to modify consumption habits.

Malaysia started its journey towards sustainable development in the 1970s, when the New Economic Policy (NEP) to eradicate poverty and restructure societal imbalances was launched. All subsequent five-year national development plans have underscored the elements of sustainable development, encompassing sustainable economic growth; growth with equitable distribution to all sections of society; balanced development; access to basic infrastructure and utilities; access to education and healthcare services; and mainstreaming of environmental conservation. These mirror the three elements of the United Nation 2030 Agenda for Sustainable Development (the 2030 Agenda), encompassing economic, social and environmental elements (EPU, 2017). The current plan, the Eleventh Malaysia Plan 2016–2020 (11MP), is aligned to most of the global Sustainable Development Goals (SDGs). One of the 17 Sustainable Development Goals (SDGs) is to eliminate hunger of any kind by 2030, by achieving food security and improved nutrition, and promoting sustainable agriculture (EPU, 2017). The priorities of the 11MP are to reach pockets of remote communities that have food and healthcare needs, to reducing the incidence of obesity, to ensure food security in the face of climate change and to accelerate the adoption of sustainable agricultural practices (EPU, 2017). The 17 sustainable development goals and 169 targets of 11MP are very ambitious, transformative and wide in scope (EPU, 2017); it is too soon to tell the effectiveness of any of these reform efforts.

3.5 CONCLUSION

The paper shows that both the transition in diet and the change in lifestyle of Malaysian over the last three decades have taken place at great speed and appear to contribute to a rapidly growing malnutrition and health problem. The multiple concurrent transitions as described in the present paper raise the problem of meeting nutritional or health requirements in an environmentally sustainable way. Rethinking and seeking a dietary model that reconciles nutritional requirements and also environment preservation is needed in this challenging situation. Malnutrition in its multiple facets – undernutrition, overnutrition and obesity, micronutrient deficiencies and diet-related non-communicable diseases (NCDs) – brings about unacceptably high healthcare, economic and social costs. Eradicating malnutrition and its costs must begin with implementation of sustainable agriculture and food systems, and its direct role in enhancing nutrition and food security deserves greater policy attention.

CHAPTER 4: MALAYSIAN FISH CONSUMPTION HABITS AND ITS SUSTAINABILITY

4.1 INTRODUCTION

Malaysia has one of the highest per capita fish supplies in the world; at around 59 kg/year in 2013, placing it the fifth place among countries with highest fish per capita supply after Maldives (184.9 kg), Iceland (91.92 kg), Kiribati (72.46 kg) and China Hong Kong (69.84 kg) (FAO, 2010). Fish is the most important animal protein source in Malaysian diet and its per capita supply has increased by about 40% between 1980 and 2013 (Chapter 2). Nonetheless, the per capita supply reported by FAO reflects "the long term trend of national per capita supply for human consumption and represents the food produced and imported into countries minus the food exported net of imports, fed to animals, or otherwise not available for human consumption, divided by population size" (FAO, 2010). It does not represent the amount of food that is actually consumed because per capita supply that was derived from food balance sheet tends to overestimate food consumption when compared with individual dietary surveys (Kearney, 2010).

Assuming that the per capita fish supply is closely proportionate to its actual consumption, there are consequences of such high fish consumption on the ecology and human health. The ever-increasing demand of fish in Malaysia will put fish stock at risk of overharvesting when more fish are caught than the population can replace through natural reproduction. In addition to overfishing, there is a number of worrying factors threatening the long term sustainability of the ocean's resources including ocean warming and acidification, aquatic hypoxia and pollution, which typically results in a feedback effect on the depletion of fish stock. Another undesirable consequence from over consumption of fish is the risk of toxic substances intake, but there is no national policy in this regard. Given that fish consumption is apparently high in Malaysia, there is a need for public health advocacy of moderated food consumption by highlighting the risk of consuming certain fish excessively. Consumers should also be given guidance on the relative environmental impacts of different fish choices.

In spite of the importance of fish in the Malaysian diet, there is no detailed studies of the magnitude and diversity of the consumption of fish by Malaysians. Comprehensive data on the amount and species consumed by Malaysian is lacking. There is also no study about the environmental concerns of Malaysian fish consumption habit and to which extent their habits contribute to the overexploitation of marine resources. The fish types available in Malaysia are remarkably diverse and each type of fish differs in terms of habitat, fishing and/or farming methods and environmental impact. Hence, it is important that a dietary survey could be conducted to produce a detailed list of the commonly consumed fish types. There is a need to understand the role that fish plays in Malaysian diet and whether or not the consumption level is adequate. On top of that, with the knowledge of species specific stocks status and their recovery process, one can assess the impacts of consumption habit on the marine resources (Hutchings, 2000).

This study is a first attempt to assess Malaysian habitual fish consumption over a 12-month reference period, with specific focus on generating baseline date to quantify the consumption of different fish species. To achieve that, a food frequency questionnaire (FFQ) was adapted to assess habitual fish consumption and subsequently conducted in Klang Valley and Selangor. The total intake of energy and macronutrients of selected populations within Klang Valley and Selangor were computed and the relative contribution of fish consumption was assessed. Dietary adequacy and the major issues and impacts of current fish consumption practices were then discussed.

4.2 METHODS

4.2.1 Study Design

The study was carried out over a five month period i.e. October 2015 to February 2016. Subjects were recruited via street-intercept in selected areas within Klang Valley and Selangor. Potential subjects were approached for screening and were informed about the study. A verbal consent was sought before being interviewed using a semi-quantitative FFQ to assess their habitual dietary intake. Subjects were given cash vouchers as a token of appreciation to improve participation rate. Demographic and anthropometric data such as weight and height were self-reported by subjects. Body Mass Index (BMI) was calculated and cut-off point was based on recommendation from WHO (2003). The basal metabolic rates (BMR) of the subjects were estimated using equation established for use in Malaysian adults (Ismail et al., 1998).

4.2.2 Study Subjects

The study subjects consisted of adults of both genders who reside in Klang Valley and Selangor. All the subjects were selected based on a purposive sampling technique. The inclusion criteria of the subjects were (1) Malaysian and Malay or Chinese or Indian ethnicity; (2) aged at least

18 years; (3) healthy and had no known illnesses; (4) able to give informed consent. Exclusion criteria were adults who have recently changed their dietary pattern and those practising special diet e.g. vegetarianism. Gay (1996) has suggested that if the population size is beyond a certain point (at approximately N=5,000), the population size is almost irrelevant, and a sample size of 400 will be adequate. Assuming a 95% confidence level with a margin error of 5%, a minimum of 385 samples were required. A total of 402 adults participated and completed the FFQ interview.

4.2.3 Development Process of the FFQ

An existing validated FFQ developed by University of Science, Malaysia (USMFFQ) was adopted for the current study. The design and methods of USMFFQ are briefly described in Chapter 2 and more detail elsewhere (Loy et al., 2011). For use in current study, adjustments to USMFFQ content had to be made because it was developed for use in the Malay ethnic only. To develop an FFQ for use in adult Malaysian population comprise of Malays, Chinese and Indian ethnic groups, a cross-culturally robust food list has to be developed. On top of that, fish was generalised and assessed as one food item on the food list of USMFFQ.

To adapt the USMFFQ for use in current study, a single 24-hour dietary recall survey (Appendix A, B and C) was conducted among 80 adults, age 18 – 60 years, in the urban Klang Valley (n=20), rural Hulu Selangor (n=40) and coastal Kuala Selangor (n=20). Unlike validation that requires minimal within-person variation, and therefore requiring multiple questionnaires to eliminate the unexplained variation, pooled data were used in current study thereby alleviating the need for multiple interviews. A total of 208 food items were pooled from these 24-hour dietary recall subjects. The food items were cross-checked against those listed in USMFFQ. Unlisted food items were selected based on a 15% frequency cut-off (Ferreira et al., 2010). Subjects of 24-hour dietary recall who reported to have consumed fish were asked to name the species of fish consumed, with support of fish photographs. On top of that, a fish availability survey was conducted. The names of fish species sold at various grocers, markets and restaurants in Klang Valley and Selangor were recorded. A comprehensive list of fish species commonly available and consumed was generated. To categorise the items on the list as wild or farmed, assumption has to be made based on comparison of data of capture fishery landing and seedling hatchery. Aquaculture consultant, fish suppliers and fishmongers were consulted to confirm if the wild fish and farmed fish were appropriately categorised.

For feasibility reasons and to reduce the burden imposed on subjects, the resulted food list were further reduced to a nested list by aggregating conceptually similar foods on the basis of their nutrient content per portion eaten. The final compiled FFQ food list (Appendix D) had 148 items categorised under 12 main food groups, which were: (1) Cereals and cereal products; (2) Meat and meat products; (3) Fish and seafood; (4) Eggs; (5) Legumes and pulse; (6) Milk and dairy products; (7) Vegetables; (8) Fruits; (9) Beverages; (10) Confections; (11) Bread spread; (12) Condiments. Summary questions on overall intake of each one of the twelve food groups were added to the FFQ for cross checking purposes. The frequency of intake was based on habitual intake over the past twelve months. There were four options in the category for frequency of intake, which were 'per day', 'per week', 'per month' and 'never'. As an interviewer administered semi quantitative FFQ, subjects were asked to estimate the number of portion size consumed relative to the portion size measurement photograph in Malaysian Atlas of Food Exchanges and Portion Sizes (Shahar et al., 2009) (Appendix E and F).

4.2.4 Validation of FFQ

Several approaches were used to validate the adapted FFQ in current study, namely, content validity, face validity and external validity. Three local nutritionists reviewed the FFQ to confirm content validity in November 2015. Comprehensibility of the newly developed FFQ was evaluated on 20 subjects. Appropriate adjustments were made based on the feedback received. In order to check the external validity of the data, the characteristics of current survey population were compared with similar data recently obtained by other sources. Neither the most common reference methods to validate an FFQ, i.e. diet records nor 24-hour dietary recall, was employed due to consideration of follow up rate.

4.2.5 Misreporting of Energy and Nutrient Intake

Misreporting, comprising both under- and over-reporting, is one of the main sources of error in dietary assessment methods (Poslusna et al., 2009). Under-reporting of usual EI includes both underrecording and undereating. Underrecording is a failure of respondents to record all the items consumed during the study period, or could be due to underestimating their amounts. Undereating occurs when subjects eat less than usual or less than required to maintain body weight (Goris and Westerterp, 1999). Establish misreporting is challenging, but even when misreporting has been identified it is often difficult to decide whether or how these data may be interpreted and used (Poslusna et al., 2009).

4.2.5.1 Determinants of Misreporting

Poslusna et al. (2009) conducted a systematic literature search to review the nature and determinants of misreporting in dietary assessment. It was found that BMI, age and sex were commonly associated with energy under-reporting. Lower socio-economic class and lower level of education were also found as predictors of under-reporting. Health-related activities, e.g. smoking and dieting, have often been linked with energy under-reporting. Psychological factors (e.g. fear of negative evaluation, social desirability, depression) and eating habits of respondents also influence misreporting. It appears that the more respondents consume, the more difficult it is to report consumption accurately, perhaps because remembering more foods or larger portion sizes is challenging or because of societal pressure to consume less.

As mentioned earlier, retrospective dietary assessment methods are memory-dependent and hence respondent memory lapses become another major factor of misreporting. The respondent either failed to recall foods actually consumed or reported foods that were not consumed during the recalled day (Gibson, 2005). Misrepresentation of portion size consumed is another major concern. Accurate quantification of the amount of food consume can be cognitively difficult. Misconceptions of an 'average' portion size can occur as respondents differ in their ability to estimate portion sizes visually. The estimation then needs a correction. The measurement aids commonly used to assist in the estimation of portion size is household measures, drawings and photographs, and food models (Poslusna et al., 2009).

4.2.5.2 Methods Used to Identify Mis-reporters

The doubly labelled water (DLW) technique is the gold standard for measuring energy expenditure under free-living conditions. The subjects are given a dose of water enriched with the stable isotopes ^{2}H and ^{18}O and urinary recovery is assessed (Subar et al., 2003). The measurement period is most usually 14 days in adults (Livingstone and Black, 2003; Poslusna et al., 2009). As with other biomarkers discussed earlier, DLW is expensive and cumbersome and deemed impractical for use in the current study. It is becoming more common to use the Goldberg cut-off as a validity check for negative bias in energy intake (Poslusna et al., 2009). The Goldberg equation calculates the confidence limits (cut- offs) that determine whether the mean reported energy intake (EI) is plausible as a valid measure of food intake (Goldberg et al., 1991), even if a dataset with a high proportion of days of genuinely low (or high) intake was produced by chance (Black, 2000).

In present study, the reported EI and basal metabolic rate (BMR) of subjects were first expressed as an index (EI/BMR), and then compared with the presumed mean EE. Estimates of basal metabolic rate (BMR) can be calculated from the Harris-Benedict formulae (Harris and Benedict, 1919) or Schofield Equation (Schofield, 1985). However, an equation established for use in Malaysian adults (Ismail et al., 1998) was deemed more appropriate for use in current study. To rule out under- and over- reporters, anthropometric measurements of subjects were recorded for calculation of energy intake/basal metabolic rate (EI/BMR) ratio. Cut-off point for EI/BMR ratio of less than 1.2 for under-reporting and more than 1.8 for over-reporting as recommended by Bingham (1994) was used. Weight status of subjects was classified according to BMI (WHO, 2017).

Table 17: Classification of body weight in adults according to BMI

(Source: modified from WHO, 2017)

Classification	**BMI (kg/m^2)**
Underweight	<18.5
Normal	18.5 – 24.9
Overweight (Pre-Obese)	25.0 – 29.9
Obese	≥30.0

The sensitivity of the Goldberg cut-off can be improved when subjects are assigned to low, medium and high activity levels and different physical activity levels and cut-off values are applied to each level (Black, 2000). However, this strategy depends on being able to choose suitable physical activity levels values, which is not always easy. It also depends on being able to measure activity or total EE in individuals. Nonetheless, the Goldberg cut-off method has high predictive value for both FFQ and 24HR (Tooze et al., 2012). Thus, even in the absence of objective measures of TEE or physical activity in current study, the Goldberg method is a reasonable approach to identify misreporting (Tooze et al., 2012).

4.2.5.3 Reporting of Data in Consideration of Mis-reporters

The occurrence of measurement error in dietary assessment can have serious consequences when interpreting dietary data from public health perspective. Under-reporting of EI could result in serious overestimates of nutrient inadequacies (Gibson, 2005) while selective under-reporting of certain food and/or food group may render the dietary data irrelevant for developing food-based dietary guidelines. In order to overcome this problem, some researchers decided to remove under-reporters from the dataset. However, because the exclusion of under-reporters introduces a source of unknown bias into the dataset, it is hence not recommended (Gibson, 2005).

A possible solution is to identify mis-reporters and to assess the intake of the group with and without mis-reporters whereby the difference between these amounts could be expressed as a degree of uncertainty (Poslusna et al., 2009). Another approach is to include all the respondents, but to control for EI by the use of energy adjustment methods. Four energy adjustment models have been proposed for when one is examining the effect of nutrients on disease outcomes: the standard multivariate model; the energy-partition model; the nutrient density model; the residual model (Livingstone and Black, 2003). The traditional and most commonly used method in nutritional studies and epidemiologic analyses is the nutrient density model (Poslusna et al., 2009). In this method, nutrient intake is expressed as a percentage of energy or as intake per 1000 kcal.

After considering and carefully weighing the arguments in the literature, the mis-reporters were not excluded from the dataset. Instead, the magnitude of misreporting was expressed in current study as the prevalence of misreporting or as the extent of under- or overestimation of intake (Poslusna et al., 2009). The nutrient density method was employed in current study for several reasons: it can be calculated directly without the use of any statistical models; it is familiar to nutritionists as a measure of dietary composition; and it has been used in national dietary guidelines (Drewnoski, 2005). However, as this method of adjustment is dependent on the changes in EI, this method cannot eliminate bias due to selective misreporting of foods; instead these methods “assume” that nutrients have been under-reported in direct proportion to energy (Livingstone and Black, 2003).

4.2.6 FFQ Analysis

Data obtained from FFQ was entered into Microsoft Excel spreadsheet. Data cleaning and quality control checks were carried out before dietary intake analysis was performed. Nutrient intakes were computed using an in-house FFQ calculator, a customised Microsoft Excel spreadsheet. This FFQ calculator is based on the participant’s frequency of consumption, amount of the item consumed and amount of nutrient in the serving size indicated. Nutrient values for each food item were derived from the Malaysian Food Composition Tables (Tee et al., 1997). For food items not available in the Malaysian Food Composition Tables, other food databases such as the Singapore Food Composition Database (Ministry of Health Singapore, 2011) and ASEAN Food Composition Tables (Puwastien et al., 2000) were sought for energy and nutrient content. For processed foods, information on energy and nutrient content on the labels was entered into the FFQ calculator directly for analysis. The macronutrient intakes reported in the present paper were based exclusively on the contribution of food and fluids consumed and did not include contribution from health supplements.

4.2.7 Statistical Analysis

Data on energy and nutrient intakes were transferred from the FFQ calculator to the Statistical Package for Social Sciences (SPSS) version 22.0 for statistical analysis. Intake distributions were presented as mean±SD and/or median, 25th and 75th percentiles to characterise population intake levels for gender, and socio-demographic characteristics (zone, strata, ethnicity, age and education level). Data associations were calculated with the Kruskal–Wallis test, Mann–Whitney U-test, independent T-test, independent median test or ANOVA, depending on normality of data, followed by Tukey or Dunnett's T3 post hoc test when necessary. Statistical significance was considered to be $p \leq 0.05$. Dietary adequacy was assessed by comparison of energy and nutrient intake with the Recommended Nutrient Intakes (RNIs) for Malaysians (NCFFN, 2005) and WHO guidelines (WHO, 2003).

4.3 RESULTS

4.3.1 Subject Characteristics

Table 18 shows the demographic characteristics of the subjects recruited into the survey. When compared to national population estimate (DoSM, 2016), current study had similar age distribution albeit slightly lower proportions of male and Malays. The respondents were on average 37.1±14.9 years old. About one-third was identified as under-reporters while over-reporters only comprised of 1.8% of the sample population. The prevalence of mis-reporters was much lower when compared to the literature. Poslusna et al. (2009) systematically reviewed and calculated that the mean prevalence of under-reporting ranged from 11.9 to 67 %, with a median at approximately 30%). Over-reporting was found in 40 % of studies evaluating the prevalence of misreporting, with a range of 3.5–7 % (median 4.1).

Table 18: Socio-demographic characteristics of subjects of current study vs Department of Statistics Malaysia (DoSM) (2016)

Characteristics	Current Study (N=391)		DoSM (2016)
	n	(%)	(%)
Gender			
Male	176	45.0	51.3
Female	215	55.0	48.7
Ethnicity			
Malay	182	46.5	57
Chinese	141	36.1	31
Indian	68	17.4	12
Strata			
Urban	191	48.8	-
Coastal	100	25.6	-
Rural	100	25.6	-
Age Group (years)			
18 – 19	28	7.2	-
20 – 29	131	33.5	30.0
30 – 39	78	20.0	28.5
40 – 49	67	17.1	18.3
50 – 59	51	13.0	12.5
>60	36	9.2	10.7
Mis-reporters			
Under-reporters	140	35.8	-
Over-reporters	7	1.8	-
True-reporters	244	62.4	-

The mean BMI of subjects of current study were compared against those of MANS 2003 and MANS 2014 in Table 19. The mean BMI in current study was at the upper extreme of normal range (24.6±4.7) kg/m^2. Generally, the BMIs of males and Malays were in the overweight range (25.1±5.3 kg/m^2; 25.4±5.3 kg/m^2). The males in current study had significantly higher BMI than females ($p<0.05$) but MANS 2003 and MANS 2014 on the other hand found that opposite is true. In current study, the Malays had the highest BMI compared to other ethnic groups. The Chinese had the mean BMI in the lower end of the normal range and their mean BMI was statistically significantly lower than Malays ($p<0.05$). MANS 2003 and MANS 2014 also found that the Chinese had mean BMI in the normal range and lower than their counterparts. A significantly positive correlation ($r=0.313$, $p<0.00$)

between age and BMI was found in current study and such trend can also be observed in MANS 2003 and MANS 2014. The over-reporters in current study had a lower mean BMI but the difference was not significant.

Table 19: Mean BMI of subjects of current study vs MANS 2003 and 2014

	Current Study (N=391) kg/m^2		MANS 2003 (N= 6886) kg/m^2	MANS 2014 (N=3000) kg/m^2
	Mean	SD	Mean	Mean
Total	24.6	4.7	24.4	25.6
Gender				
Male	25.1*	5.3	24.2	25.0
Female	24.1*	5.1	24.6	26.2
Ethnicity				
Malay	25.4*	5.3	24.9	26.01
Chinese	23.6*	4.8	23.6	24.5
Indian	24.4	4.8	24.5	26.8
Strata				
Urban	24.4	4.9	24.4	25.6
Coastal	24.7	5.4	-	-
Rural	24.7	5.2	24.4	25.6
Age Group (years)				
18 – 19	22.1	4.6	21.4	22.0
20 – 29	23.5	5.4	23.5	24.7
30 – 39	25.0	5.3	24.9	26.0
40 – 49	25.1	4.6	25.5	26.4
50 – 59	26.1	4.3	25.67	26.4
>60	26.0	4.2	-	-
Mis-reporters				
Under-reporters	24.8	5.1	-	-
Over-reporters	20.6	6.3	-	-
True-reporters	24.5	5.0	-	-

*significant difference found at p<0.05

It was found that 41.7% of the study population was overweight or obese. The overall prevalence of overweight and obesity was higher in current study than in MANS 2014. While prevalence of overweight was indifferent to ethnicities, obesity, in general, was less prevalent among Chinese. Unlike MANS 2003 and MANS 2014, the Chinese in current study had higher prevalence of being underweight. Spearman's correlation test suggested that BMI was weakly positively associated with CHO intake (r=0.191, p<0.00), but negatively with protein (r=-0.12, p<0.05) and fat (r=-0.192, p<0.00).

Table 20: Prevalence of different weight status among subjects of different ethnicities in current study vs MANS 2003 and 2014

Weight Status	Ethnicities		
	Malay %	Chinese %	Indian %
Normal			
Current Study	46.2	51.8	52.9
MANS 2003	48.5	58.2	43.8
MANS 2014	38.3	51.2	41.4
Overweight			
Current Study	29.1	25.5	25.0
MANS 2003	27.2	25.0	31.0
MANS 2014	32.9	31.9	28.1
Obese			
Current Study	18.7	8.5	16.2
MANS 2003	15.3	7.2	12.7
MANS 2014	22.0	10.8	28.1
Underweight			
Current Study	6.0	14.2	5.9
MANS 2003	9.1	9.7	12.6
MANS 2014	6.8	5.5	2.9

While overweight and obesity were increasingly prevalent among Malaysian adults, undernutrition still prevails (Table 20), especially in the younger population. In current study, 68% of the underweight adults are below 25 years old and 74.3 % of them resided in the urban area. Studies have shown that the phenomenon of double burden of malnutrition is more prevalent in urban than rural areas of developing countries, particularly among low income households, but gradually increasing in the rural areas (Doak et al., 2005; Jehn and Brewis, 2009; Oddo et al., 2012; Lee et al., 2012).

4.3.2 Energy Intake

Table 21 presents the distribution of energy intake of Malaysian adults before exclusion of mis-reporters. The total mean energy intake was 1609.6 kcal/person/day and was similar to the result of MANS 2014 (i.e. 1615.0 kcal/person/day). The exclusion of mis-reporters resulted in mean energy intake increasing by 18.3% to 1903.6 ± 557.9 kcal/capita/day. The exclusion of mis-reporters has improved the agreement between BMI and total calories intake, from r=0.106 ($p<0.05$) to r=0.247 ($p<0.00$). MANS 2014, however, did not exclude mis-reporters from the data set.

Similar to the trends found in mean BMI, gender and ethnicity were found to have significant impact on total energy intake. After exclusion of mis-reporters, the mean energy intake of men was significantly higher (2141.0 kcal) than that of women (1699.9 kcal) (Table 22). Among the three major ethnic groups in Malaysia excluding mis-reporters, Malays had the highest intake of energy (2028.5 kcal) while the Chinese had the lowest energy intake (1722.4 kcal) (Table 22). The difference was statistically significant. In general, energy intake did not differ among all age groups. By strata, all respondents had similar mean energy intakes.

Table 21: The distribution of energy intake of subjects of current study
before exclusion of mis-reporters vs MANS 2014

Characteristics	Current Study (N=391) (kcal/person/day)					MANS 2014 (kcal/person/day)	
	Mean	±SD	Median	Percentiles		Mean	Median
				25	75		
Gender							
Male	1819.4	726.1	1748.1	1275.3	2205.7	1776.0	1722.0
Female	1437.8	653.8	1325.0	979.4	1668.3	1447.0	1400.0
Ethnicity							
Malay	1809.4	786.8	1688.1	1250.2	2120.2	1653.0	1579.0
Chinese	1379.5	547.3	1315.5	979.0	1676.2	1567.0	1492.0
Indian	1551.8	656.5	1388.6	1091.1	1796.5	1431.0	1370.0
Strata							
Urban	1575.5	721.2	1447.5	1078.1	1932.2	1601.0	1512.0
Coastal	1606.4	680.3	1501.0	1127.6	1953.4	-	-
Rural	1677.8	728.1	1569.8	1125.6	2038.7	1635.0	1575.0

Age Group (years)							
18 – 19	1447.9	486.6	1415.2	1072.2	1712.1	1621.0	1571.0
20 – 29	1688.7	815.8	1493.3	1085.5	2038.5	1665.0	1595.0
30 – 39	1635.9	608.1	1621.1	1178.8	2008.6	1660.0	1567.0
40 – 49	1572.3	752.6	1379.8	1087.5	1846.7	1555.0	1501.0
50 – 59	1573.5	674.9	1446.2	1149.7	1959.6	1503.0	1443.0
>60	1511.0	635.7	1409.4	1034.1	1888.0	-	-
Mis-reporters							
Under-reporters	995.4**	261.8	981.7 [a**]	803.4	1183.3	-	-
Over-reporters	4074.4**	600.2	3837.2 [a**]	3617.4	4639.2	-	-
True-reporters	1904.0**	557.9	1792.7 [a**]	1500.1	2159.9	-	-

[a] independent samples median test; **p<0.00

Table 22: The distribution of energy intake of (kcal/d) subjects of current study after exclusion of mis-reporters

Characteristics	Total True-reporters (N=244) (kcal/person/day)				
	Mean	±SD	Median	Percentiles 25	Percentiles 75
Gender					
Male (n=113)	2141.0**	544.1	1997.4 [a**]	1748.1	2460.9
Female (n=131)	1699.9**	485.6	1589.3 [a**]	1339.1	1913.4
Ethnicity					
Malay (n=124)	2028.5**	558.0	1914.3 [a**]	1614.0	2351.3
Chinese (n=76)	1722.4**	482.4	1621.6 [a**]	1336.5	2006.0
Indian (n=44)	1866.1	598.4	1662.8	1404.2	2159.8
Strata					
Urban (n=118)	1887.0	619.7	1776.2	1468.9	2159.8
Coastal (n=64)	1936.0	619.7	1792.3	1518.3	2236.7
Rural (n=62)	1902.8	516.0	1859.8	1514.6	2218.0
Age Group (years)					
18 – 19 (n=16)	1778.5	356.4	1662.6	1533.5	2087.3
20 – 29 (n=79)	1954.6	633.3	1863.8	1450.1	2376.5
30 – 39 (n=52)	1946.1	479.6	1853.8	1614.9	2182.6
40 – 49 (n=40)	1855.4	549.7	1780.3	1461.3	2066.9
50 – 59 (n=33)	1900.7	595.3	1846.6	1435.4	2132.6
>60 (n=24)	1814.4	542.0	1685.6	1332.8	2112.8

[a] independent samples median test; **p<0.01

The mean energy requirement was estimated based on mean BMI. When energy balance is at equilibrium (maintenance of current weight status), it appears that an average female and male adult would require 1860kcal and 2232kcal. Assuming all subjects were maintaining their weight status, current study was estimated to have underestimated the actual mean energy intake of female and male subjects by 9.4% and 4.3%.

4.3.3 Macronutrients Intake

In current study, the median percentages of total energy contributed by macronutrient were 62% for carbohydrate, 15% for protein and 23% for fat. MANS 2003(2014) reported that the median percentage was 59% (55%) for carbohydrate, 14% (16%) protein and 27% (29%) fat.

4.3.3.1 Carbohydrates Intake

Overall, the mean carbohydrate intake was 150.8±20.2 g/1000kcal. The urbanites consumed significantly less carbohydrates than the rural dwellers. No gender, ethnicity and age differences were found (Table 23).

Table 23: The Mean ± SD intake of Carbohydrates of Subjects of Current Study

Characteristics (N=391)	Carbohydrates (g/1000kcal)	
	Mean	±SD
Gender		
Male (n=176)	151.7	23.4
Female (n=215)	150.1	17.3
Ethnicity		
Malay (n=182)	152.1	19.9
Chinese (n=141)	148.5	21.3
Indian (n=68)	152.4	19.0
Strata		
Urban (n=191)	148.3*	21.6
Coastal (n=100)	152.4	20.3
Rural (n=100)	154.2*	16.6
Age Group (years)		
18 – 19 (n=28)	156.44	15.0
20 – 29 (n=131)	147.71	20.9
30 – 39 (n=78)	149.54	25.0
40 – 49 (n=67)	150.60	16.9
50 – 59 (n=51)	153.94	17.3
>60 (n=36)	156.56	18.0

*p<0.05

4.3.3.2 Protein Intake

The mean of total protein intake was 36.4± 8.2 g/1000kcal, of which a mean of 20.8±11.9 g/1000kcal comprised of animal protein. The plant to animal protein ratio was 3:4. Geographical location, gender and ethnicity were found to be significant determinants of animal protein intake (Table 24): urbanites consumed more animal protein than their counterparts did; male consumed significantly more animal protein than the female; Chinese consumed significantly more animal protein than the Malay while Indians consumed the least. Total protein intake, on the other hand, was similar among all groups (Table 24).

Table 24: The Mean ± SD intake of Total Protein and Animal Protein of Subjects of Current Study

Characteristics (N=391)	Total Protein (g/1000kcal)		Animal Protein (g/1000kcal)	
	Mean	±SD	Mean	±SD
Gender				
Male (n=176)	35.7	8.0	22.2*	13.2
Female (n=215)	37.0	8.3	19.7*	10.6
Ethnicity				
Malay (n=182)	37.0	7.8	20.0*	11.4
Chinese (n=141)	36.6	8.6	24.1*	12.8
Indian (n=68)	34.7	8.2	16.4*	9.2
Strata				
Urban (n=191)	37.1	8.4	22.8*	12.9
Coastal (n=100)	36.3	8.2	17.5	8.8
Rural (n=100)	35.3	7.6	20.4	11.9
Age Group (years)				
18 – 19 (n=28)	35.3	5.4	17.7*	9.0
20 – 29 (n=131)	37.2	9.0	21.1	12.8
30 – 39 (n=78)	37.6	8.0	24.7*	12.7
40 – 49 (n=67)	36.1	8.2	19.8	10.8
50 – 59 (n=51)	34.9	7.7	18.0*	8.3
>60 (n=36)	35.3	7.4	20.1	13.2

*p<0.05

Consistent with the findings of Food Balance Sheet review in Chapter 2, the FFQ results shows similar ranking and proportions of fish as the largest contributor of animal protein (34.5%), followed by chicken (26.8%) and egg (17.9%) (Table 25). Lamb (2.0%) and duck (0.7%) were unpopular among the subjects of current study (Table 25). Geographical location, gender and ethnicity continued to play important role in the type of animal protein consumed. It was found that male consumed significantly less fish and more beef and lamb. Malays consumed significantly more beef than Chinese and Indians. Because of a significant number of Buddhism and Hinduism followers among the Chinese and Indian, the proportion of beef intake among these two ethnics groups was very low. On average, the Chinese consumed significantly less fish but more pork. Considering religious sensitivity, pork was not included in the list of food items during interviews with Malays (as Malays are constitutionally required to be Muslims). Thus, zero consumption of pork among Malays was assumed. By strata, the urbanites consumed the least proportion of fish. As a higher proportion of ethnic Chinese resides in urban area, the consumption of pork was significantly higher in the region. Spearman's correlation test suggested that age was positively associated with fish consumption (r=0.147, p<0.00).

Table 25: The Percentage Contribution of Different Sources of Animal Protein Intake of Subjects of Current Study

Characteristics (N=391)	% of Animal Protein (excl. milk)						
	Fish	Chicken	Egg	Pork	Beef	Lamb	Duck
Total	34.6	26.8	17.9	10.3	7.7	2.0	0.7
Gender							
Male (n=176)	31.1*	27.0	17.5	11.2	9.9*	2.7*	0.6
Female (n=215)	37.5	26.6	18.2	9.6	5.9	1.4	0.8
Ethnicity							
Malay (n=182)	39.6	28.2	15.9*	0.0**	13.3**	2.6	0.4
Chinese (n=141)	23.9**	27.7	19.9	24.7**	2.0	0.7**	1.2*
Indian (n=68)	43.7	21.3*	18.9	7.9**	4.6	3.0	0.7
Strata							
Urban (n=191)	30.5*	27.6	17.6	12.6*	8.6	2.1	1.1*
Coastal (n=100)	39.9	27.3	19.2	6.8	5.0*	1.6	0.2*
Rural (n=100)	37.1	24.9	17.1	9.5	8.6	2.2	0.6

*p<0.05; **p<0.00

The estimated amount of fish consumed was 122g/day (44.5kg/year) of raw weight after exclusion of mis-reporters. On average, per capita fish consumption was substantially higher in coastal (51.9kg/year) and rural areas (51.8kg/year) than in urban areas (36.9kg/year). In 2008, a group of researchers funded by the Ministry of Health Malaysia conducted a cross-sectional survey to investigate patterns of fish consumption among Malaysian adults in Peninsular Malaysia using a 3-day prospective food diary (Ahmad et al., 2016). The study subjects were comprised of 14.7% Chinese, 8.3% Indian and 77% Malay. The results revealed that those who resided in Central region (i.e. Klang Valley, Selangor and Negeri Sembilan) consumed 147g/day (53.7kg/year) of fish. Current study included only Klang Valley but not Negeri Sembilan (which is less urbanised hence higher fish consumption) and had much lower proportion of Malay respondents thus explains the differences in estimated per capita fish consumption.

The Ministry of Health Malaysia (2010) recommends one serving of any type of fish a day, assuming 14 g of protein per serving (Appendix G and H). On average, there is about 20g of protein in every 100 g of edible portion of raw fish. In Malaysia, fish are normally served whole; hence, after accounting for an average of about 50% of edible portion, the recommended serving of fish is equivalent to 140 g of unprepared fish (i.e. uncooked, bone-in) per day. While both the coastal and rural dwellers were consuming about 142g of unprepared fish a day, enough to meet the dietary guideline, the urbanites were on average consuming about 100 g of unprepared fish daily, which is 30% short of the recommended amount. On the other hand, it was found that the respondents of current study were, on average, consuming two servings of meat and poultry per day, i.e. one-fold more than the recommended serving. The recommended serving for meat and poultry for a 2000-calorie average diet is one serving, assuming 14g of protein per serving (Appendix H).

Table 26: Popularity of top 15 fish and products by prevalence and weight from FFQ of current study

Rank	English Name	Prevalence of consumption (%)	Rank	English Name	Annual per capita weight for total population (kg)
1	Anchovies	54.2	1	Indian Mackerel	7.11
2	Indian Mackerel	48.1	2	Spanish Mackerel	3.45
3	Vannamei Prawn	32.7	3	Red Tilapia	2.31
4	Black Pomfret	31.2	4	Stingray	1.89
5	Spanish Mackerel	29.4	5	Black Pomfret	1.53
6	Red Tilapia	26.9	6	Small Tuna	1.27
7	Blood Cockles	23.3	7	Vannamei Prawn	1.26
8	Sardine	21.5	8	Round Scad	1.24
9	White Pomfret	21.2	9	Barramundi	1.16
10	Sea Prawns	21.0	10	Catfish	1.16
11	Tiger Prawns	20.2	11	Threadfin Bream	1.05
12	Stingrays	17.9	12	Tiger Prawn	0.95
13	Barramundi	15.3	13	Hardtail Scad	0.95
14	Threadfin Bream	14.6	14	White Pomfret	0.95
15	Fish ball	14.3	15	Sea Prawn	0.87

Footnote: Latin names of the fish listed can be found in Appendix I.

Referring to Table 26 and 27, most of the commonly consumed fish on a weight basis in current study were scombrids (Indian mackerel, Spanish mackerel, small tuna) or carangids (pomfrets and scads) that are solely wild captured. When annual per capita weight of the most consumed fish among subjects in current study was compared by strata, mackerel consistently appeared as the most consumed fish (Table 27). Both the data from current study (Table 26) and MANS 2003 (Ahmad et al., 2016) showed high popularity of mackerels and anchovies by prevalence of consumption. While mackerels and anchovies are solely wild captured, Vannamei prawn that was ranked the third most popular fish by prevalence of consumption is solely farmed, hence making Vannamei prawn the most prevalently consumed farmed product.

Table 27: Annual Per Capita Weight (g) of Top 15 Most Consumed Fish across Different Geographical Locations in Current Study

	Urban		Rural		Coastal	
Rank	English Name	Per Capita Consumption (kg/year)	English Name	Per Capita Consumption (kg/year)	English Name	Per Capita Consumption (kg/year)
1	Indian Mackerel	5.43	Indian Mackerel	6.33	Indian Mackerel	11.12
2	Sardine	3.38	Spanish Mackerel	5.12	“Keropok Lekor”	8.23
3	Spanish Mackerel	3.27	Red Tilapia[pf]	4.17	Stingray	2.98
4	Red Tilapia[pf]	2.04	Sardine	3.66	Threadfin Bream	2.34
5	Barramundi[p]	1.74	Round Scad	2.28	Small Tuna	2.13
6	Black Pomfret	1.47	“Keropok Lekor”	2.28	Spanish Mackerel	2.13
7	Stingray	1.44	Black Pomfret	2.12	White Pomfret	1.61
8	“Lala” Clam	1.24	Catfish[pf]	2.09	Sardine	1.48
9	“Keropok Lekor”	1.24	Barramundi[p]	1.86	Tiger Prawn[pf]	1.35
10	Salmon[p]	1.19	Big Head Carp[pf]	1.54	Sea Prawn	1.28
11	Vannamei Prawn[pf]	1.12	Vannamei Prawn[pf]	1.54	Vannamei Prawn[pf]	1.25
12	Round Scad	0.93	Hardtail Scad	1.52	Fourfinger Threadfin	1.23
13	Tiger Prawn[p]	0.81	Red Snapper[p]	1.34	Black Pomfret	1.08
14	Small Tuna	0.80	Stingray	1.33	Sole Fish	1.03
15	Blood Cockles[p]	0.78	Small Tuna	1.31	Red Tilapia[pf]	0.97

Footnote: Latin names of the fish listed can be found in Appendix I; p =predominantly farmed; f =freshwater

Referring to Table 27, the rural consumed the most farmed and freshwater fish, followed by the urbanites. The coastal dwellers, on the other hand, had high affinity for wild marine fish. Only one farmed species, i.e. red tilapia ranked at 15th, was listed in the top 15 most consumed fish. The coastal dwellers also consumed the highest amount of prawns (tiger prawn, wild sea prawn and Vannamei prawns combined). All of the commonly consumed fish species are endemic to Malaysia, except salmon. Salmon, a relatively expensive fish as it is solely imported, appeared as the 10th most consumed fish (by weight) in the urban region. It is, however, the least common fish in the rural and coastal regions. The urbanites also consumed the most bivalves. *Keropok lekor*, a traditional fish finger commonly made with mackerel fish flesh, was a popular snack among the respondents, especially in the coastal region.

Table 28: The distribution of percentage of farmed fish out of the total amount of fish consumed by subjects of current study

	Percentage of Farmed Fish Out of Total Fish Consumed (%)				
	Mean	±SD	Median	Percentiles	
				25	75
Total (N=391)	24.9	26.1	16.2	3.5	42.3
Gender					
Male (n=176)	28.1*	27.9	18.7	4.9	44.5
Female (n=215)	22.3	24.2	14.3	1.6	40.7
Ethnicity					
Malay (n=182)	22.2	23.2	14.4	3.3	39.5
Chinese (n=141)	31.0*	28.4	20.3*	5.5	51.0
Indian (n=68)	19.8	26.5	7.7	0.5	30.3
Strata					
Urban (n=191)	26.1	27.3	15.7	1.5	46.3
Coastal (n=100)	20.0	22.8	13.3	3.8	27.3
Rural (n=100)	27.7	26.3	19.6	5.3	43.7
Age Group (years)					
18 – 19 (n=28)	27.0	33.4	11.5	1.7	41.2
20 – 29 (n=131)	31.0	29.7	22.9	3.0	49.1
30 – 39 (n=78)	22.8	21.1	15.8	4.6	41.6
40 – 49 (n=67)	21.2	23.8	10.3	3.9	39.6
50 – 59 (n=51)	20.7	20.5	16.1	3.7	30.5
>60 (n=36)	18.9	23.5	12.2	0.9	25.7

*p<0.05

Overall, a mean and median of approximately 25% and 16% of fish consumed by the sample population was farmed (Table 28). About 17% (n=68) of the sample population had 50% of their total fish consumption comprised of farmed fish (which mainly comprised of Vannamei prawn). The males and Chinese consumed significantly bigger proportion of farmed fish than their counterparts ($p<0.05$) (Table 28). The coastal dwellers consumed a significantly smaller proportion of farmed fish than their counterparts (Table 28). No significant difference was found across age group though it appeared that respondents below 40 years old were more likely to consume a bigger proportion of farmed fish (Table 28).

4.3.3.3 Fat Intake

The mean of total fat intake was 24.9±6.2 g/1000kcal, of which a mean of 10.7±2.9 g/1000kcal comprised of saturated fatty acids (SFA) (Table 29). Mean intake of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) were 9.3±2.9 g/1000kcal and 4.3±1.4 g/1000kcal, respectively (Table 29). No significant difference was found across all groups except that ethnic Chinese consumed significantly lesser SFA.

Table 29: The Mean ± SD intake of Total Fat, SFA, MUFA and PUFA of Subjects of Current Study

	Total Fat (g/1000kcal)		SFA (g/1000kcal)		MUFA (g/1000kcal)		PUFA (g/1000kcal)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Total (N=391)	24.9	6.2	10.7	2.9	9.3	2.9	4.3	1.4
Gender								
Male (n=176)	25.1	6.4	10.7	2.9	9.3	2.9	4.3	1.5
Female (n=215)	24.8	6.1	10.6	2.9	9.3	2.9	4.2	1.3
Ethnicity								
Malay (n=182)	25.1	6.0	11.0	2.7	9.3	2.7	4.3	1.3
Chinese (n=141)	24.6	6.6	10.1*	3.1	9.4	3.1	4.3	1.4
Indian (n=68)	25.1	5.9	11.0	3.0	9.1	3.1	4.1	1.4
Strata								
Urban (n=191)	25.5	6.7	10.8	3.1	9.4	3.1	4.3	1.5
Coastal (n=100)	24.1	6.4	10.4	2.8	9.3	3.0	4.1	1.3
Rural (n=100)	24.5	5.0	10.6	2.6	9.2	2.4	4.3	1.2
Age Group (years)								
18 – 19 (n=28)	22.7	7.3	9.8	3.0	9.1	2.7	4.3	1.2
20 – 29 (n=131)	25.8	6.3	11.0	2.9	9.8	2.9	4.5	1.3
30 – 39 (n=78)	25.5	6.8	10.5	2.8	9.5	3.1	4.4	1.6
40 – 49 (n=67)	25.2	6.1	11.0	3.1	9.2	3.0	4.3	1.5
50 – 59 (n=51)	23.6	4.7	10.3	2.5	8.5	2.3	3.8	1.1
>60 (n=36)	23.5	5.5	10.2	3.3	8.5	2.7	3.8	1.3

*p<0.05

Overall, total fat, SFA and PUFA comprised of 22.5%, 9.6% and 3.8% of total calories intake. Fats consumption pattern of subjects in current study met minimum requirements of dietary guidelines. WHO suggested that total fat should not exceed 30% of total energy intake (WHO, 2008) while RNI Malaysia suggested keeping SFA below 10% of total EI. As for PUFA, WHO suggested that a range of 3.6-11.2% of total calories should be consumed (Ministry of Health Malaysia, 2005).

4.4 DISCUSSION

The FFQ conducted in current study has given an insight to the adequacy of current fish consumption practices. In general, most of the respondents were consuming enough fish to meet the Malaysian dietary guidelines (Appendix H), except for the urbanites that were on average consuming 30% short of the recommended amount. However, one should note that the recommended dietary guideline for fish in Malaysia is much higher than the common suggestion in the other parts of the world. For instance, the British Dietetic Association (BDA, 2016) and American Heart Association (AHA, 2016) recommend at least two portions of fish a week, including one of oily fish. The stark difference in the recommended serving of fish may be down to the fact that the fatty acid composition of fish in Malaysia's tropical water differs from that of the temperate region as fish generally has higher content of beneficial long chain polyunsaturated fatty acids at lower temperatures. It may also be attributed to the fact that eating fish has always been an important part of Malaysian tradition and culture. However, it is worth noting that the dietary guideline of Singapore, a country which was once a part of Malaysia before breaking off in 1965 and thus shares similar cultures, also recommends its citizen to aim for two servings of fish a week (Ministry of Health Singapore, 2014). Nonetheless, the Malaysian recommendation of at least one serving of fish a day was stipulated without first evaluating its sustainability and health risks.

Intake of fish and long-chain fatty acids of marine origin has been associated with many benefits, such as reduced risk of coronary heart disease (CHD); however, there are also several contaminants present in fish, such as methylmercury (MeHg) and persistent organic pollutants (POPs), which have been associated with adverse health effects (Hellberg et al., 2012). For certain type of fish, especially the oily fish, the maximum amount of consumption was determined by the British Dietetic Association and American Heart Association due to the fear of toxic pollutants (BDA, 2016; AHA, 2016). As such, health and environmental considerations should also be integrated into the Malaysian dietary guidelines. If the fish consumption pattern maintains, as it has been in the past (Chapter 2), consumers should be well-informed of the health risks and environmental impacts of their fish choices. There is a need to incorporate into the national dietary guidelines a national list of fish that can be eaten freely or moderately and fish that should be avoided, considering several perspectives, with information integrating health, ecological, and economic impacts of different fish choices (Oken et al., 2012).

Fish is the most important protein source in the Malaysian diet that is still primarily gathered from the wild rather than farmed—with marine captured fish accounting for more than 75% of the total fish consumed in current study. Generally, the local diet constitutes mainly those from wild captured small pelagic fish that are from lower trophic levels such as mackerels and sardines. Beside economic reason it is worth noting that eating habit and dining style of Malaysian especially the Malay ethnic group, which is the ethnic majority, is inclined towards small fish serving. The big or high value fish such as crustacean is normally served in restaurant and of high demand during festive season. This consumption habit has high ecological impact. As a result to continuously high demand of small and lower grade fish species, Malaysia needed to import as a means to ensure enough supply for its people. As of 2014, Malaysia was a net importer for a number of popular fish consumed in current study, i.e. mackerels, sardines, scads, rays and pomfrets. The deficit in trade was highest for mackerels (DoFM, 2014). Great portion of the imported fisheries commodities were from Thailand and Indonesia (DoFM, 2014). The fact that the Malaysian fish demand has to be fulfilled by supplies beyond its domestic waters implore a more responsible use of resources in order to avoid depleting fish stocks in other parts of the world (Swartz et al., 2010). Furthermore, there are also concerns about "food miles" and carbon dioxide emissions related to the supply chain that need to be accounted as environmental impacts of imported food commodities (Kissinger 2012).

To assess the stock status, the list of most commonly consumed fish obtained from FFQ findings was checked against the International Union for Conservation of Nature (IUCN) Red list database. The IUCN is a membership Union uniquely composed of both government and civil society organisations and the Red List is set upon precise criteria to evaluate the extinction risk of thousands of species and subspecies. It was found that only a few but not all commonly consumed fish were listed on the database due to general lack of reliable data in the region. There was no information on population or general abundance of Indian mackerels, the most popular fish consumed. It is not known how this species population is affected by current and historical fishing pressure but the IUCN acknowledged that there was some evidence of localised declines and fishing effort was assumed to be increasing. On the other hand, the overall catches of stingrays were reported to be declining, with fishermen having to travel further and further to sustain catch levels. Some species of ray was assessed as "Near Threatened", considered to be close to meeting the criteria for "Vulnerable" as a result of past, ongoing and future declines caused by the high level of exploitation in the region. Avoidance of this species should be recommended.

For small tuna, while stock status remained stable, IUCN highlighted that the overall trends in catch may mask declining trends for individual species because annual landings were often dominated by the landings of a single species. These fluctuations seemed to be partly related to unreported catches, as these species generally comprised part of the bycatch and were often discarded, and therefore did not reflect the real catch. Another commonly consumed fish on the IUCN Red list is the commercially trawled Threadfin Bream (Nemipterus furcosus). It was believed that the capture production of this fish was gradually decreasing in Malaysian waters, however, nothing was known of the Nemipterus furcosus population in Malaysian water. Scads are subject to heavy exploitation and are reported to be overexploited. On the Sunda shelf (extension of the continental shelf of South East Asia) the annual landings of scads have suffered a 51.5% decrease from 1994 to 2004, despite an increase in fishery effort of around 50% for the same period. However, this reported decline is only known from a small part of this species range.

Local fish landing statistics do not provide reliable clue of sustainability of fish stock. Stobberup (2011) acknowledged that there is a major gap in the coverage of small-scale (traditional) fisheries. The presence of unlicensed fishers is a long standing issue in Malaysia that is openly acknowledged, but has not been properly addressed (Teh and Teh, 2014). This has been in part due to the poor socio-economic status of traditional fishers, which has led to an informal policy among fisheries agencies to not require traditional fishers to obtain fishing vessel or gear licenses (Teh and Teh, 2014). Since annual national landings statistics report catches from licensed fishers and fishing vessels only, underestimation of total catches is inevitable. Predictably, the historical and present levels of fishing are higher than accounted for by fisheries regulatory agencies. In light of this issue, Teh and Teh (2014) reconstructed marine fisheries catches for Peninsular Malaysia from 1950-2010. The reconstruction suggested that from 1950-2010, marine catches in Peninsular Malaysia were underestimated by factors of 1.8 while unlicensed fishing potentially resulted in an additional 25.9 million tonnes of fish taken from the waters of Peninsular Malaysia in the period under consideration.

On the other hand, one finding in current study that sparks debate for environmental and healthy sustainability is the low plant to animal protein ratio at 3:4. The proposed optimal dietary protein is at least 4:1, plant to animal, with the traditional Mediterranean diet as a standard (Burlingame, 2014). What is worse is that the average respondents were consuming 100% more meat and poultry than recommended. The production of animal generally requires much more land area, water and energy inputs, and produces more greenhouse gases than the production systems for most food plants, with one likely exception – fish. In the EPIC-Oxford cohort study, the estimated GHG emission for fish eaters was found to be similar to vegetarians while in self-selected meat-eaters are approximately twice as high as those in vegans (Scarborough et al., 2014). However, fish consumption pattern and fish production system differ between the UK and Malaysian contexts, hence, further investigation is required. Nonetheless, the increasing consumption of terrestrial animal in diet, if left uncontrolled, will have detrimental effects to the health of nation, especially so when overweight and obesity is becoming a national epidemic. Such concern is resulted from the expected adverse effects of saturated fat (SFA) in meat on low-density lipoprotein and total cholesterol levels.

There is convincing evidence that replacing SFA with PUFA decreases LDL cholesterol concentration and the total/HDL cholesterol ratio and thus the risk of CHD (WHO, 2008). The minimum intake levels of PUFA to prevent deficiency symptoms are estimated at 2.5 – 3.5% (WHO, 2008) but the minimum recommended level to be effective for decreasing the risk of CHD events is 6% (WHO, 2008). It is well known that fish lipids are the main sources of PUFAs, especially EPA and DHA (Osman et al., 2001). Despite high consumption of fish, the PUFA intake (3.8%) of subjects in current study is at the lower extremity of WHO recommendation. A handful of papers have found that a few less popular local fish species are potential sources of essential fatty acids (EFA) in meeting the recommended nutrient intake (Osman et al., 2001; Osman et al., 2007; Ng, 2006; Wan Rosli et al., 2012; Muhamad and Mohamad, 2012; Mohd and Abdul Manan, 2012; Abd Aziz et al., 2013). Endinkeau and Tan (1993) even found that the EFA levels in a local freshwater eel, the "*belut* sawah", are comparable to those of salmon. However, recommending the increased consumption of selected fish is an area where the feasibility of dietary recommendations needs to be balanced against concerns for sustainability and potential depletion of fish stocks.

One limitation of this study is that only the amount of total PUFA, but not its composition, consumed in Malaysian diet was estimated due to shortcoming of the databases. The Malaysian Food Composition Database has no information of fatty acid composition and hence references to the Singaporean databases had to be made. Unfortunately, the Singaporean database only provides total PUFA values for all food items involved whereas the information for n-3 fatty acids, EPA and DHA is only available for a limited number of food items. Also, the Malaysian Food Composition Database that was used in current study may have misestimated the levels of nutrients because it has not been updated since the first revision 20 years ago. It was published in 1988 and has only been revised once in 1997. Due to the fast-paced evolution of the food industry, the nutritional value of food might have evolved altogether. For instance, a UK study found that chicken contains more than twice as much fat as it did in 1940, a third more calories and a third less protein (Wang et al., 2009).

The inherent weakness of FFQ in terms of absolute accuracy was expected. After accounting for mis-reporters, the FFQ result of current study was deemed as a very close estimate as it was found that the mean energy intake of female and male subjects fall short by only approximately 9% and 4% of estimated energy requirement for weight maintenance, respectively. The slight differences observed may arise from the use of dated food composition database. It may also be attributed to the difficulty of weeding out under-reporting of food intake by some subjects. Another factor could be the lower levels of activity and sedentary lifestyle in the study population: the high prevalence of overweight and obesity in current study can result from a minor energy imbalance leading to a gradual, but persistent, weight gain over a considerable period of time. It is common to find reported energy intake inadequate to meet the recommended allowances for a given free-living population with the random occurrence of error and inherent limitation of dietary assessment methods (Ismail et al., 1998). For instance, the daily median energy intake of Malaysia adults as reported by MANS 2014 was 36% short of the Recommended Nutrient Intake (RNI) despite having employed well-trained nutritionists for dietary surveys.

The animal protein consumption pattern differed significantly across the highly segmented consumer groups and such differences have important implications for future studies. The generalisability and comparability of current FFQ findings are subjected to gender, ethnic and regional differences. The regional difference in terms of consumption of wild or farmed and marine or freshwater fish was evident. Future studies on fish consumption should take these differences into account. In this current study, the sustainability of fish consumption were only discussed based on landing statistics, import transactions and the limited knowledge of stocks status. For a complete perspective, future study could include other criteria/indicators of sustainability e.g. life cycle assessment, eco-efficiency, management of wastes and total energy costs. More importantly, one should understand that fish is only one component of a sustainable diet. To achieve the ultimate goal, there is an immediate need for integrative, cross-sectoral, and population-wide researches that address the full range of components of unsustainable food production and consumption.

4.5 CONCLUSION

The increasing demand of animal protein exerts an increasing pressure on the livestock sector, especially for fisheries. As the biggest contributor of animal protein in Malaysian diet, it was found that fish protein comprised of about one-third of total animal protein consumed. Current study has found that the average per capita fish consumptions in coastal, rural and urban areas were 51.9kg/year, 51.8kg/year and 36.9kg/year respectively. Those from the coastal and rural areas are consuming enough to meet the recommended dietary guideline but that is not the case for those in the urban area. To meet dietary guideline, the urbanites would have to consume about 30% more fish. Nonetheless, the Malaysian dietary guideline for fish consumption (Appendix H) is exceptionally high and hence should be re-evaluated from the sustainability and health risks perspectives. The study confirmed the role of wild-captured fish as the prime source of animal protein and has discussed signs of unsustainability of this consumption habit. It is suggested that the Malaysian dietary guideline for fish be made specific to revising down wild fish and alternating it with sustainably farmed ones to protect and allow recovery of the depleting wild fish stock. It also raises the question of whether the recommended guideline of one serving of fish a day should be pressed on when the average population is already consuming more animal protein than needed. While a change in habit is not likely to occur in the near future, the demand for wild fish is expected to increase with increasing population and the increasing awareness of fish as a health food. Wild fish stocks are not infinite, and have to be rationally exploited to ensure their sustainability. With evidence of depleting fish stocks and high import bills, it is apparent that the fish consumption pattern of Malaysian cannot be sustained in a long run and deserves immediate attention.

CHAPTER 5: OPPORTUNITIES AND BARRIERS TO THE EXPANSION OF THE AQUACULTURE INDUSTRY

5.1 INTRODUCTION

Generally, the local demand for fish constitutes mainly wild captured fish such as mackerel, sardines and scad (Chapter 3). A review into the status of fish stock, reconstructed national fish landing statistics and fish trade statistics has found that the amount of local wild fish supply is significantly lower than the potential demand (Chapter 3). Underestimation of fish landing is prevalent due to unregulated unlicensed fishing which undermines the sustainability of fisheries. A number of commonly consumed fish was found to be heavily exploited. To cater for continued high demand, Malaysia needed to import these fish from countries like Thailand and Indonesia. Consequently, the amount of import bill grew tremendously, putting Malaysia as a net importer of fish since 2008 until today.

To meet the projected demand for fish, further impetus is given to enhancing aquaculture development in national policies. It is hopeful that the fish supply and demand equilibrium can be achieved by promoting aquaculture activities. In a move to develop the aquaculture industry, the Department of Fishery Malaysia (DoFM), has initiated the Aquaculture Industrial Zone (AIZ) Program involving the development of 49 zones, located across Malaysia, which will be used for culture of various types of high value aquatic species (Yusoff, 2015). The DoFM has identified several strategic areas that would be developed for downstream activities such as fish seed production, feed mills, fish processing plants, and other supporting industries (Yusoff, 2015). Although aquaculture is becoming economically more important as a way of increasing local fish production for food security, its production is still very small compared to capture fisheries: it contributes less than 0.2 percent to GDP (FAO, 2009). On top of that, farmed fish are underutilised as it accounts for about 25% of total fish consumed (Chapter 3).

In 2009, during a regional workshop co-organised by FAO and the Network of Aquaculture Centres in Asia and the Pacific (NACA), participants, including representatives of DoFM, were asked to critically reflect on their own experiences through a “strengths, weaknesses, opportunities and threats (SWOT)” analysis of the aquaculture policies in their countries (FAO, 2010). A number of weaknesses and threats have been identified by DoFM as hindering the growth of the industry (Table 30). The DoFM cited climate change, non-point pollution, disease, dependence on imported raw material for formulated feed, competition among other producers, non-tariff barriers and economic downturn as major threats to the local aquaculture industry. It was also highlighted that the national planning process and aquaculture policy only involve big private sector, which only represents about

10% of all aquaculturists. Such national plans and policies were more focus to increase balance of trade and less people oriented and less focus on the environment, climate, as well as the livelihood of target groups. These big players usually farm the high value products for export purpose which may not be relevant to the domestic market. The issue of low popularity of aquaculture products among local consumers was not raised.

Table 30: SWOT analysis as proposed by DoFM representatives at 2009 Regional workshop (FAO, 2010)

SWOT analysis of Malaysia's national planning process and aquaculture policy

Strengths – Existing or potential resources or capability – Participatory at all different levels in department – Full implementation of M&E activities – Development of system of accountability through IT – Policy covers long- and short-term with reviews along the way	**Weaknesses** – The existing or potential internal force that could be a barrier to achieving objectives/results – Only involve big private sector (representing around 10% of aquaculturists) – Production target set by central agency – Less focus on international needs (climate change, market needs, importing country requirements, etc.) – More focus to increase BOT and less on environment, people, livelihood of target groups.
Opportunities – The existing or potential factors in the external environment that, if exploited, could provide a competitive advantage – Global demand of fish due to health consciousness – Natural fish resources declining worldwide – Newest aquaculture technologies available – New demand for live organic fish – Increasing demand on Halal product	**Threats** – The existing or potential force in the external environment that could inhibit maintenance or attainment of unique advantage. – Climate change – Non-point pollution – Disease threat – Dependence on imported raw material for formulated feed – Competition among other producers – Non-tariff barriers – Economic down turn

It is apparent that the capacity and potential of the aquaculture industry remain under-utilised for the domestic market. Social studies therefore play a vital role here to help understand the underlying factors to the lack lustre performance. While the SWOT analysis prepared by DoFM provided helpful clues to the weaknesses and threat to the expansion of the aquaculture industry in Malaysia, it was a dated document and the situation might have already changed since then. Some old problem might have already been solved while new problems arise. There might also be an apparent disconnect between theory and practice as the apparent poor consumer preference was not recognised and discussed. An up to date market research is essential to aid in the understanding of current market situation of wild-caught and farmed fish and their products in Malaysia, and more importantly to understand the challenges to the popularisation of farmed products.

5.2 METHODS

After considering the literacy levels, available resources and geographical factors, a semi-structured interview via telephone was selected as the method of data collection. In order to elicit views from two perspectives, the subjects consisted of not just aquaculturists but also the wholesalers. The retailers were excluded because it was thought that their narrow market experience may not be relevant to the highly segmented market. It was decided that a semi-structured questionnaire that allows for extra information prompting would be more suitable for the exploratory nature in current study. The semi-structured questionnaires included a mixture of open and close ended questions. Semi-structured interviews are commonly used in exploratory studies to provide further information about the research area (Harvard University, 2001). Combining within one interview one section of factual, structured questions and one section of semi-structured questions designed to explore the responses from the first section (Harvard University, 2001). As aquaculturists and wholesalers are of different business natures, one set of semistructured questionnaire was customised specifically for each of the marketers, although both sets shared similarities. The questionnaires were translated to another two languages (i.e. Malay, and Chinese) before converted into a computer assisted telephone survey script in the format of fillable "Portable Document Format" (PDF) forms.

5.2.1 Questionnaire for Wholesalers

The questionnaire (Appendix J) was designed to obtain information related to:

a. Business operations - Forms and species of products sold, source and origin of products, relative contributions of wild and farmed fish in total sales, types of primary customers

b. Size of business - Number of workers, total revenue, geographical location/distributions, sales volume and value

c. Perceived opportunities and barriers related to the production and/or marketing of farmed fish using key points listed out by the officials of DoFM as discussed earlier

d. Perceived customers' preference and need.

e. Perceptions about aquaculture product from wholesalers' point of view in terms of various product attributes as compared to wild fish. Items were adapted from previous studies (Verbeke et al., 2007; Claret et al., 2014). Results from this section are discussed in Chapter 6.

5.2.2 Questionnaire for Aquaculturists

The questionnaire (Appendix K) was designed to obtain information related to:

a. Business operations - Forms and species of products sold, types of primary customers

b. Size of business - Number of workers, total revenue, production volume, size of farm
Number of units, geographical location/distributions, sales volume and value, characteristics of patrons

c. Perceived opportunities and barriers related to the production and/or marketing of farmed fish using key points listed out by the officials of DoFM as discussed earlier

d. Perceived customers' preference and market trend and need.

e. Perceptions about aquaculture product from aquaculturists' point of view in terms of various product attributes as compared to wild fish. Items were adapted from previous studies (Verbeke et al., 2007; Claret et al., 2014). Results from this section are discussed in the Chapter 6.

5.2.3 Administration and Analysis of the Questionnaire

The study took place from January – June 2014. First, fishery business directories were obtained from Department of Fisheries, Malaysia. Purposive sampling method was then used to select businesses that were identified as aquaculturists and wholesalers. A representative of the chosen marketer must be one of the decision makers in the firm and/or oversee the production or supply chain. The business must be based in Peninsular Malaysia. Each potential respondent was contacted in advance and the nature of the interview was explained to them. Consent and permission were sought before scheduling an appointment on when the interview would be held over the phone. When necessary, the respondents were contacted again to confirm the date and time of the interview. The questionnaires were piloted on 3 aquaculturists and 3 wholesalers and improvement were made accordingly before the actual survey took place. The telephone survey was conducted whilst seated at a computer. Close-ended survey questions were administered strictly adhering to survey scripts while open-ended questions were administered with reference to interviewer prompt. Respondents were let to tell their story and probing questions were asked whenever necessary. Questioning styles such as the use of content mapping and mining techniques and explanatory probing, as described by Ritchie and Lewis (2003), were used. The interview soon felt like a natural exploratory conversation.

Closed-ended responses were entered directly into the computer while open-ended responses were entered with the use of shorthand. Since the responses were entered directly into the computer the data was instantaneously processed. Each interview took a minimum of 20 minutes. The interviews were not tape-recorded due to the lack of suitable resources. On top of that, tape recording was also deemed as disadvantageous because after the interview, the interviewer has to play the whole tape through again, sorting out what is wanted and what is not. The common alternative is to make notes using shorthand. For newspaper journalists, this is often the more common method. For court reporting, this is the only method of recording which is permitted. Extensive time was needed to conduct, transcribe and analyse a multilingual semi-structured interview. Therefore, the number of interviews scheduled had to take into account available time and resources. It was also important to consider the fact that respondents were business owners or company directors in high demand and therefore not always available.

Data collection from respondents ended once data saturation was achieved for open-ended questions, i.e. when interviews do not provide any new or additional insights because the information gathered was repetitive. After each interview, the researchers search for new themes, and look out for novel ways of perceiving situations. With thematic analysis, the open-ended data was reworked or ‘reduced’ to represent major themes or categories that describe the phenomenon being studied. In this way the coding frame was continuously developed in response to new information until the point where new interviews or focus group transcripts did not provide any new themes relevant to the research focus. At this point theoretical saturation was said to be reached. Closed-ended responses were summarised and presented in frequency tables.

5.3 RESULTS

5.3.1 Wholesalers' Profile

A total of eleven wholesalers were interviewed. All eleven owners of fish wholesale business interviewed refused to reveal information of their revenue for the past year but confirmed that their business was functioning and making profit. It was only revealed that these businesses were of small and medium sizes, with the number of employees ranged from 3 to about 100 people. All of the businesses were based in Klang Valley.

5.3.1.2 Best Selling Fish Species

Wholesalers were asked to list their five best-selling fish species in the past year. Best-selling items were predominantly marine pelagic fish, of which consists of a variety of mackerels and scads, as well as prawns (Table 31). Approximately 60% of wholesalers reported to have sold farm-raised aquatic animal products but only 27.3% included the term "farmed raised" or "aquacultured" as a marketing tool. Farmed species sold included but not limited to Vannamei prawn, Dory, barramundi, groupers, snappers, tilapia and salmon.

Table 31: The % figures indicate the percentage of all wholesalers who included that species in their list of Top 5 bestselling species in the past year

No.	English Name	%
1	Indian Mackerel	55
2	Scads	45
3	Prawns	36
4	Mackerel Tuna	27
5	Threadfin Bream	18
6	Black Pomfret	18
7	Barramundi	18
8	Tilapia	9
9	Catfish	9
10	Salmon	9

5.3.1.3 Purchasing Channel

Wholesalers generally acquired their products from more than one source (Figure 13). The most prevalent source was from abroad, with near to half of the wholesalers importing their products. About a quarter of them purchased from primary harvesters or sourced from their own farm; less than 20% of them harvested themselves or purchased from major wholesalers for reselling.

Figure 13: Prevalence of purchasing stock from various sources

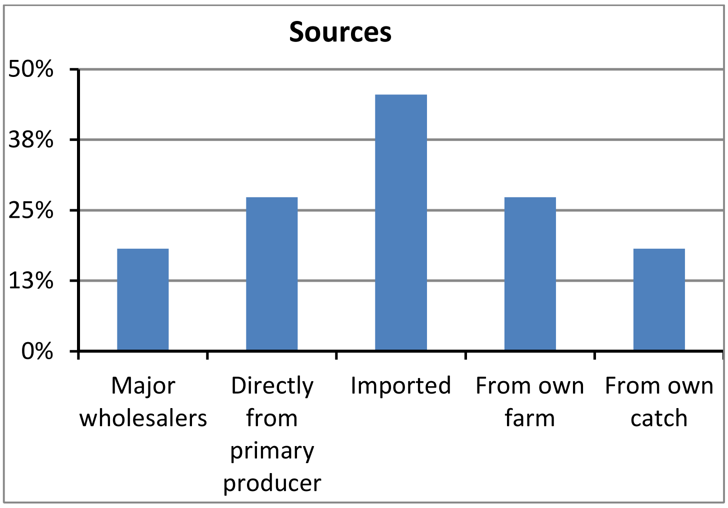
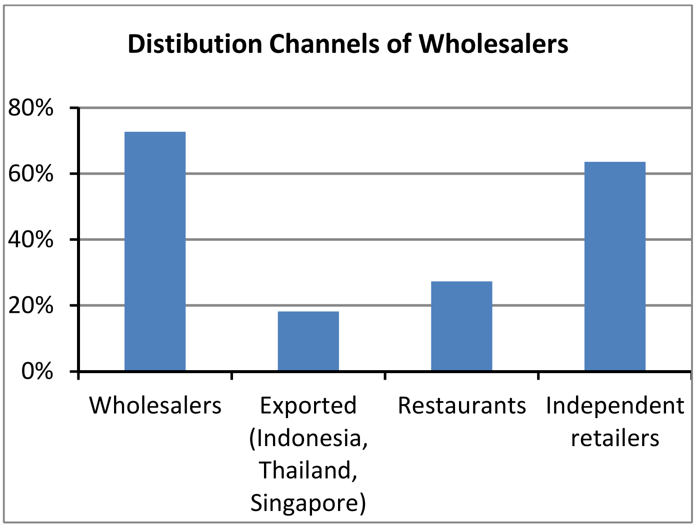


Figure 14: Distribution channels of wholesalers

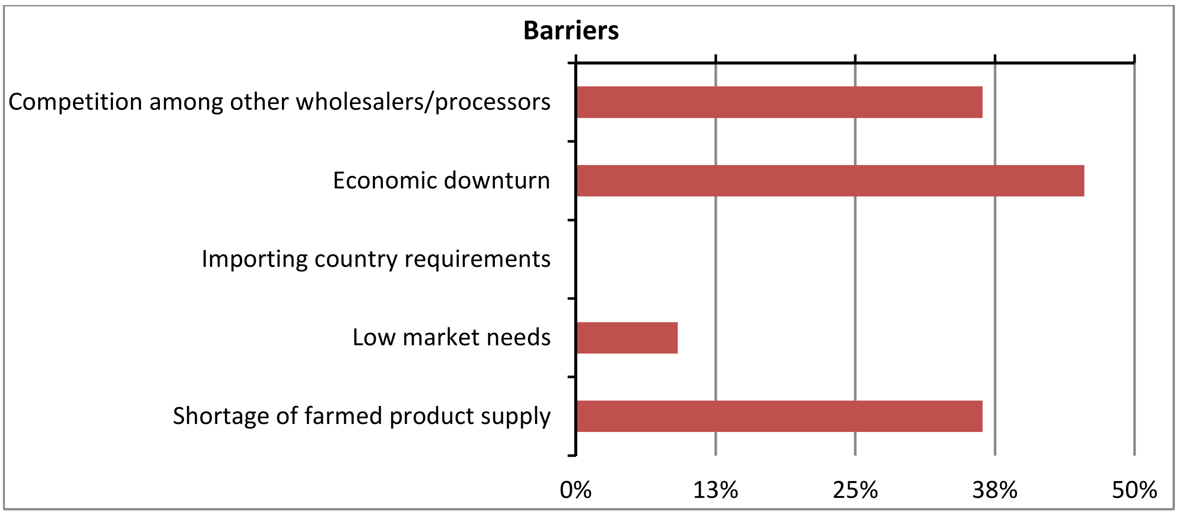


Wholesalers channelled their products to different clienteles (Figure 14). A vast majority of them resold to wholesalers or independent retailers. Less than 30% of them distributed to restaurants while less than 20% of them export their products to Indonesia, Thailand and/or Singapore.

5.3.1.4 Barriers and Opportunities of Market Expansion

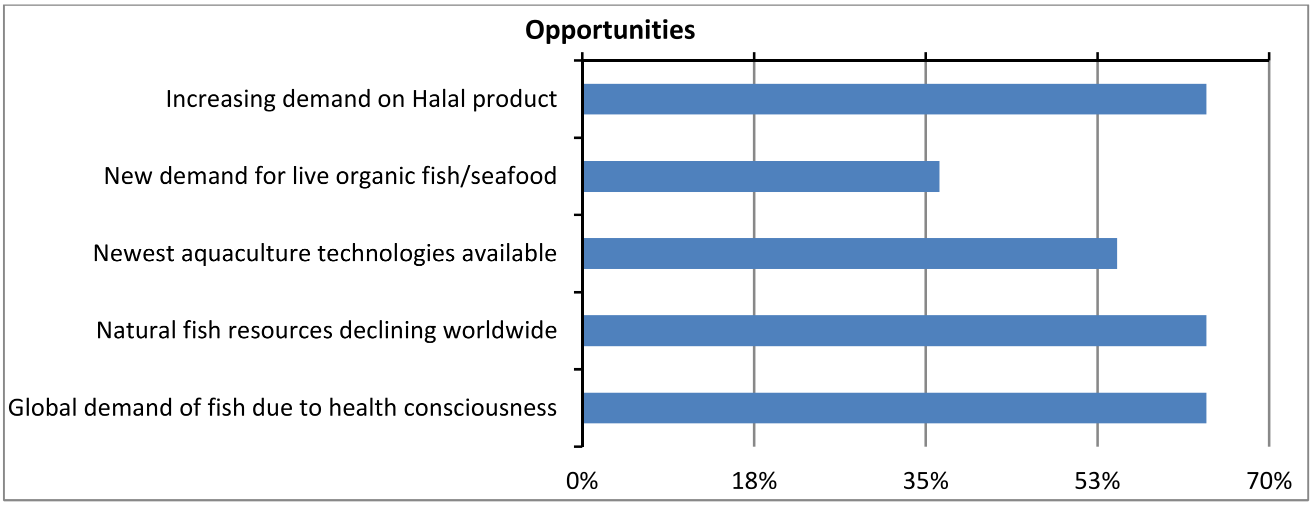
Almost half of the wholesalers cited economic downturn as the main barrier of expansion (Figure 15). They explained that inflation would increase operational costs of farms (thus reducing revenue) and would slow down sales as local consumers are price-sensitive. In times of economic crisis, it was thought that consumers would look for cheaper fish or even chose to eat less fish. Some wholesalers stated that cheap farmed fish e.g. tilapia or catfish are infamous for their "muddy taste" so consumers would likely pick cheap wild-captured pelagic fish instead. In fact, the wholesalers who cited low market needs were referring specifically to the "cheap farmed fish with muddy taste" that suffers lower consumer preference. The rest of the wholesalers stated the high demand of farmed products from restaurateurs. Only farmed prawns were cited as susceptible to shortage (due to disease), while other farmed fish species are mainly unaffected. About one-third of wholesalers voiced out that price war as a form of unhealthy competition among other wholesalers has impeded the growth of the industry (Figure 15). Open-ended responses included lack of skilled manpower, lack of suitable land resources, lack of governance on pollution issue and public prejudice against farmed fish.

Figure 15: Wholesalers' perceived barriers to the expansion of aquaculture industry



Overall, the wholesalers largely agreed that increasing global demand of fish unmatched by declining natural fish resources will be the key opportunity for the expansion of aquaculture industry (Figure 16). Wholesalers cited rapid population growth and advertisement promoting fish consumption as the reasons behind increasing local demand. Interestingly, it was also suggested that consumers turn to eating fish because chicken is "chemical laced" while fish is perceived as healthier option. However, the increasing demand of fish may have to be matched by expansion of aquaculture industry as wholesalers cited natural fish stocks are declining due to low reproductive rate and habitat destruction. It was also revealed that demand for prawn has never been fully satisfied by local production (whether wild or farmed) and therefore has always needed to be imported from neighbouring Indonesia and Thailand. The aquaculture industry, particularly prawn farms, was thought to would be benefit from new technologies that help curb diseases and early mortality. About one-third of the wholesalers thought that fish labelled as "organic" can fetch price premiums but only wild-captured deep sea fish are associated as "organic" and that the idea of organic farming of fish may be difficult to materialise.

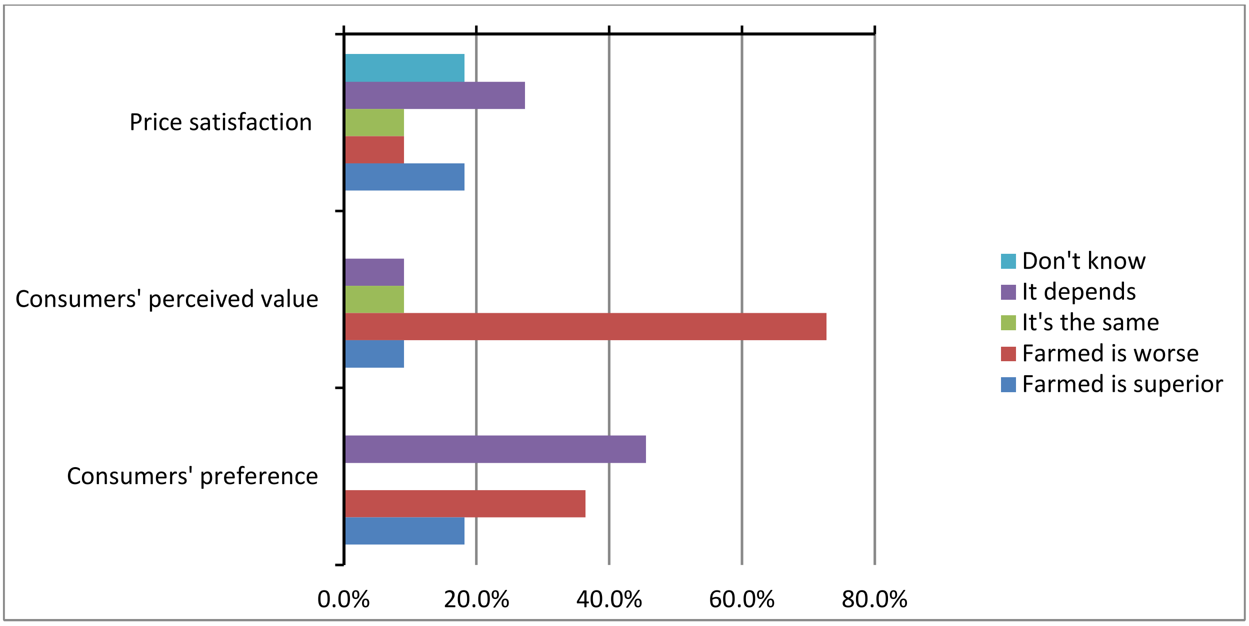
Figure 16: Wholesalers' perceived opportunities for market expansion



5.3.1.5 Wholesalers' Perceived End-Users' Attitude about Aquaculture Products

While majority of the wholesalers (72.7%) perceived that consumers regarded farmed fish as "low-value fish" (Figure 17), they thought that consumers' preference is dependent on other factors regardless of whether the products were farmed or wild-captured. They claimed that while the coastal dwellers may be "more knowledgeable" and are able to "differentiate between farmed and wild-captured fish", more than often "only less than 5% of laymen end-users know about the origins of fish" and that the end-users would just "refer to price tag" and would prefer "whichever is fresh yet affordable". Responses for perceived price satisfaction are divided. Generally, it was perceived that restaurateurs, with a specific menu to adhere to, would be more satisfied with farmed products for their price stability and that layman end-users would just buy the more affordable types.

Figure 17: Wholesalers' perceived end-users' attitude about aquaculture products



5.3.2 Aquaculturists' Profile

A total of thirty seven aquaculturists were interviewed. Thirty-three aquaculturists refused to reveal information of their revenue for the past year. Three aquaculturists reported revenues ranging from RM 30,000 to 1.8 million while one aquaculturist reported a loss. The number of employees range from 0 to about 800 people. All of the businesses are based in Peninsular Malaysia.

5.3.2.1 Farmed Fish Species

Aquaculturists were asked to list the fish types that they farmed in the past year. The most prevalent type was prawn while farmed fish were predominantly of marine or brackish water, e.g. barramundi, groupers, snappers.

5.3.2.2 Distribution Channels of Farmed Fish

Aquaculturists channelled their products to different clienteles. A vast majority of them resold to wholesalers or independent retailers (Figure 18). About 30% of them distributed to restaurants (Figure 18) while less than 50% of them export their products to Hong Kong, Singapore, Australia and China (Table 32).

Figure 18: Distribution Channels of Farmed Fish

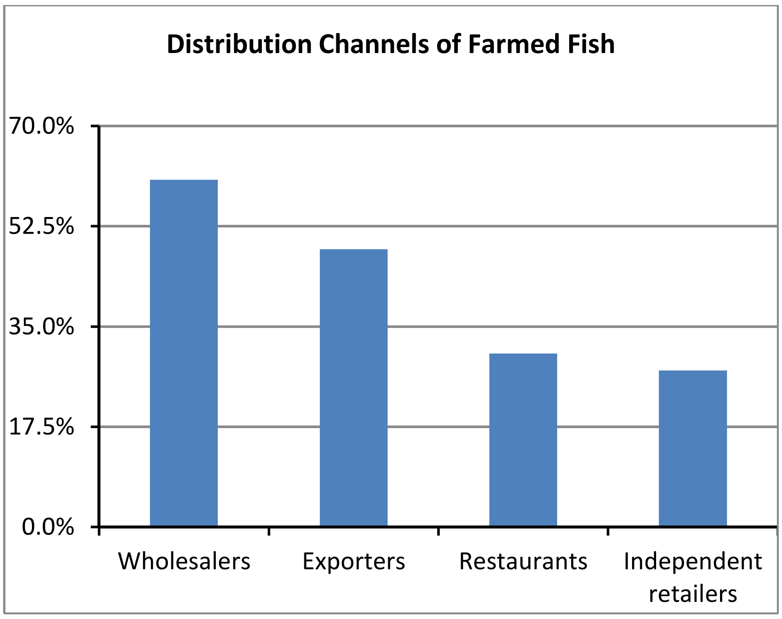


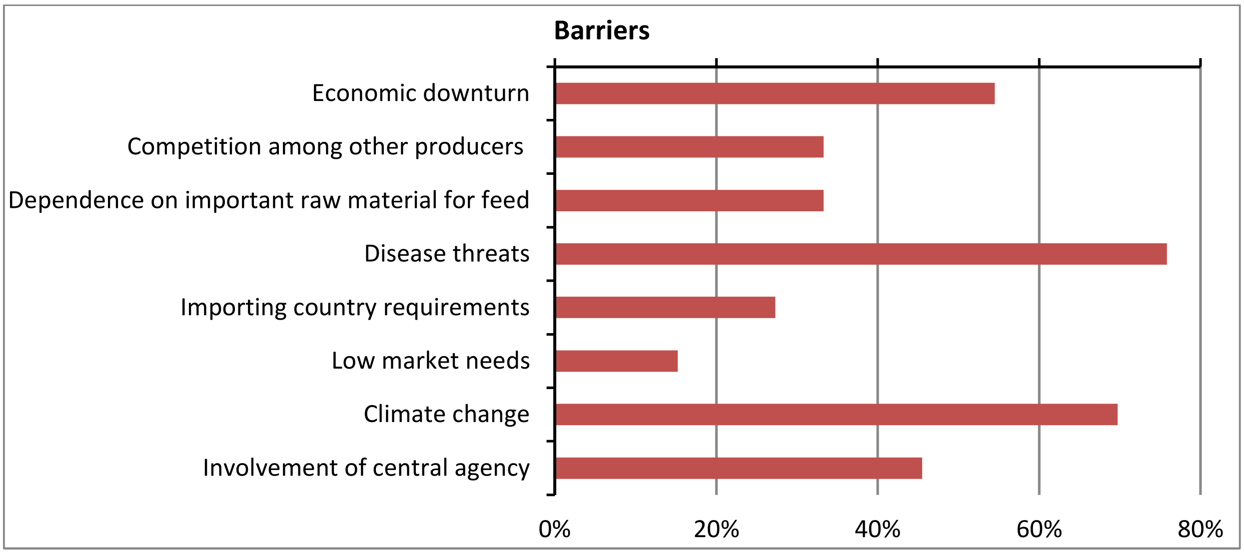
Table 32: Export Destinations of Farmed Fish

Export Destinations	Percentage
Hong Kong	43.8
Singapore	43.8
Australia	18.8
China	18.8
America	12.5
Taiwan	6.3
Japan	6.3
South Korea	6.3
Brunei	6.3

5.3.2.3 Aquaculturists' Perceived Barriers and Opportunities of Market Expansion

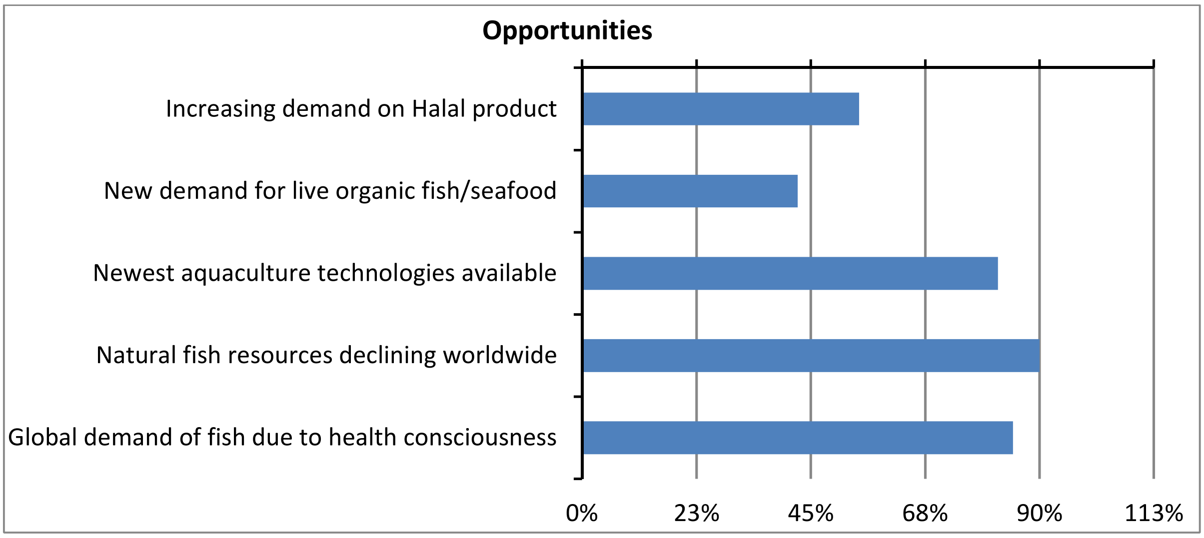
About 45.5% of the aquaculturists said that their current production is not enough to meet the market demand (Figure 19). The main reason cited was that international market demand is growing at a faster pace than the fish could grow. More than 70% of the aquaculturists cited disease threat as the main barrier of expansion of prawn farms because prawn farms are highly susceptible to diseases and fish farms could be infected if in close vicinity to the prawn farms. Other important barriers include climate change (69.7%), economic downturn (54.5%) and involvement of central agency (45.5%) (Figure 19). About one-third also cited competition among other producers, inconsistent supply of fishmeal and strict importing country requirements as barrier to expansion (Figure 19). Open-ended responses suggested that in recent years, the weather in Malaysia has become more unusual with extreme weather pattern and hence more effort is required to maintain the quality of farm water. It was claimed that when the weather is extreme, there is a significant reduction in the landing of trash fish hence affecting the supply of fishmeal. Added to the constraint is that economic downturn would encourage consumers to be more thrifty in spending. Aquaculturists thought that consumers would look for cheaper fish or even choose to eat less fish; they would dine out less frequently and lower sales volume for restaurants would mean lower demand for farmed fish. It was said that higher value species i.e. groupers and prawns will be affected the most while demand for cheaper alternative i.e. barramundi will remain if not increase. A vast majority of farm owners complained about the lack of governmental support stemming from preferential policies. Other problems related to involvement of central agency were difficulty to get approval in land acquisition and high export tax. On top of that, the lack of governance on the import of cheap products from Thailand and Indonesia to compete in local market was thought to have also affected the livelihood of local aquaculture industry. However, it was also mentioned that DoFM was helpful in terms of acquiring relevant health certificates for exporting purpose. The quality threshold set by importing countries has been increased and small farms find it difficult to cope. Other open responses include: pollution, lack of manpower due to difficulty to hire foreign labour, insufficient supply of fish fry, low survival rate of fish fry and lack of fund or capital as a result of difficulty to get loan.

Figure 19: Aquaculturists' perceived barriers to the expansion of aquaculture industry



Overall, the aquaculturists largely agreed that the decline in natural fish stocks coupled with increasing global demand of fish and improved aquaculture technologies will be the key opportunity for market expansion (Figure 20). However, a few aquaculturists highlighted that the widespread negative perception of farmed fish among consumers will only cause the demand for wild-captured fish to increase and such negative perception has to be scrapped by implementing good farming practices. The decline in natural fish stock was not well received by aquaculturists who depend on trash fish as fish feed. While some suggested that new technology that boosts resistance against disease and climate change would encourage the growth of aquaculture industry, other owners were sceptical to the effectiveness and affordability of new technology, if any. It was suggested that there was an increasing demand of fish in affluent Middle Eastern region but such demand had already been satisfied by African and Indian suppliers. Other aquaculturists suggested that this Halal opportunity was only relevant in local Malaysian market. The majority of aquaculturists (62.2%) were clueless about the definition of "organic farming" and were sceptical of its practicality (Figure 20).

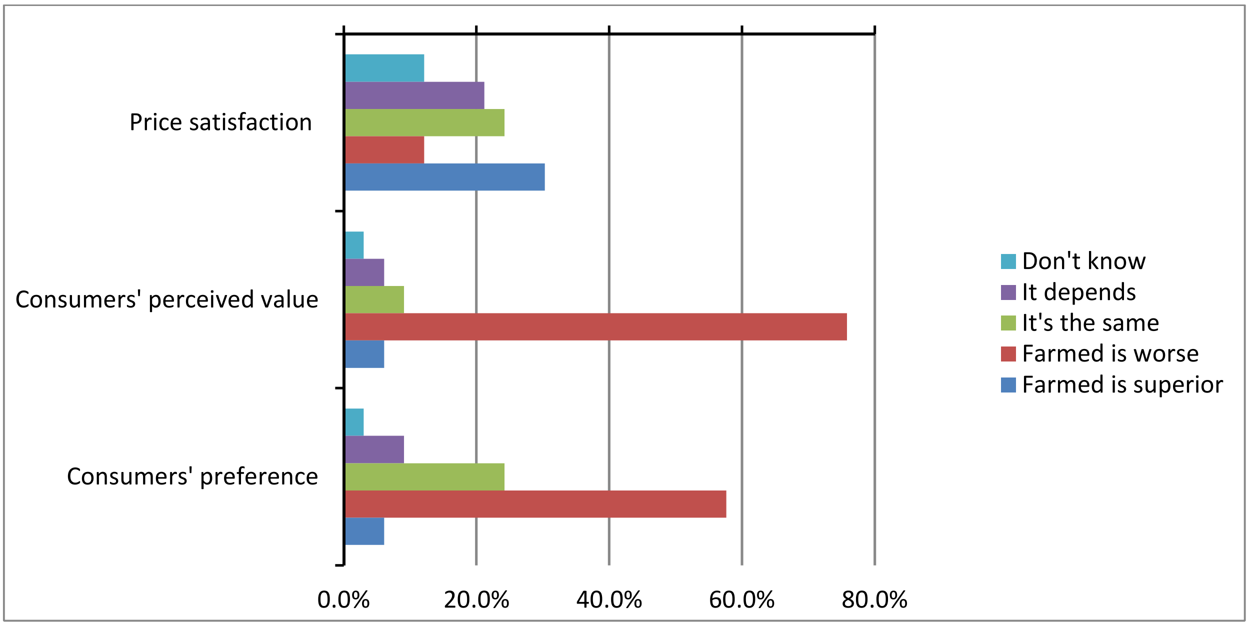
Figure 20: Aquaculturists' perceived opportunities of market expansion



5.3.2.4 Aquaculturists' Perceived End-Users' Attitude about Aquaculture Products

A majority of the respondents perceived that consumers would not prefer to have farmed fish (51.5%) and regarded farmed fish as low-value (67.6%) (Figure 21) as they thought that poor consumers' preference is mainly due to negative image and perception on intensive agricultural farming in general. They claimed that while the coastal dwellers may be "more knowledgeable" and are able to "differentiate between farmed and wild-captured fish", more than often "urban dwellers do not know what they are buying; even if they asked the fishmonger, they will not be told the truth". They suggested that consumer preference is dependent on other factors regardless of whether the products were farmed or wild-captured. It was perceived that the end-users would choose based on freshness, price, appearance and smell. Responses for perceived price satisfaction are divided. Generally, similar to the wholesalers, the aquaculturists also perceived that restaurateurs, with a specific menu to adhere to, would be more satisfied with farmed products for their price stability and that layman end-users would just buy the more affordable species.

Figure 21: Aquaculturists' perceived end-users' attitude about aquaculture products



5.4 DISCUSSION

The market research has provided a better understanding on the challenges to the popularisation of farmed products from the wholesalers' and aquaculturists' point of view. The challenges as told by these industrial players can be broadly categorised into four factors, according to the FAO technical paper, "Understanding and Applying Risk Analysis in Aquaculture": natural/environmental, economic/financial, biological and social (Bondad-Reantaso et al., 2008). These factors can be caused by external or internal vulnerabilities, and some may be avoided through pre-emptive action. The internal business environment includes factors within the organisation that impact the approach and success of operations. Social factors such as labour shortage, self-induced risks due to irresponsibility, bad press and consumer prejudice are factors that could be worked upon for improvement. The external environment consists of a variety of factors outside the organisations that the businesses typically do not have much control over. These include (i) Natural/environmental: abnormal climatic pattern, water and land quality degradation; (ii) Economic/financial: market volatility, financial crisis, cheaper substitutes and trade disputes, crop loss (production uncertainties), difficulty acquiring loan; and (iii) Biological: pathogens and diseases, growth or capacity to reproduce of the culture species (low availability and survival rate of fish fry), shortage of fish meal. Respondents in current study had highlighted social and economic/financial factors that were not mentioned previously by DoFM.

Upon comparison with the responses gathered in current study, it was found that the issues that threaten the aquaculture industry as raised by DoFM back in 2009 were still largely unsolved. Climate change, pollution, disease threat and the heavy reliance on trash fish as fish feed were cited as significant challenges that affected the livelihood of aquaculture industry in current study. Climate change has profound impact on water availability and weather patterns (e.g. extreme amount of rainfall), and these impacts aggravate the eutrophication and stratification in already polluted waters (De Silva et al., 2009). Another important, though indirect, impact of climate change on aquaculture is the limitations on fishmeal and fish oil availability (for fish feeds) as a result of a reduction in raw material supplies (De Silva et al., 2009). While DoFM recognised the importance of newest aquaculture technologies for the expansion of the market, respondents in this study were less optimistic about it, mainly because of the disappointment arose from the lack of progress in aquaculture technology innovation as well as the expensive price tag that came along with new technology. Long term environmental problems coupled with the lack of strategies and solutions could partially explain why the industry has not been able to achieve projected production and sales target.

Vannamei prawn, which is a local favourite farmed shellfish and the most important fishery commodity to generate export income (accounted for 45% of total fisheries export income in 2014), has been a subject of increasing attention in recent year. Pollution loading and the clearing of mangroves for prawn farm construction have been quoted as causing deterioration in the state of coastal natural resources and the environment. Like coral reefs, mangrove forests are extremely productive ecosystems that provide numerous good and services both to the marine environment and people. Mangrove forests are home to a large variety of fish, crab, shrimp, and mollusc species. These fisheries form an essential source of food for thousands of coastal communities around the world. The forests also serve as nurseries for many fish species, including coral reef fish. For example, a study on the Mesoamerican reef showed that there were as many as 25 times more fish of some species on reefs close to mangrove areas than in areas where mangroves had been cut down (Alba, 2015). This makes mangrove forests vitally important to coral reef and commercial fisheries.

The best-selling fish reported in current study were comparable to the most consumed types found in FFQ, which indicates good applicability of the information provided by wholesalers to the research setting. With nearly half of the wholesalers claimed having had to import fish (e.g. mackerels, scads and prawns) to fulfil local demand, the hypothesis that Malaysian's fish preference and consumption pattern is unsustainable is further strengthen. In fact, the latest available data from the Department of Fisheries Malaysia (DoFM) (2014) shown that Malaysia was the net importer of the most commonly consumed captured fish since 2008, signifying that local catches were not sufficient to satisfy local needs. It is no wonder that DoFM and almost all wholesalers and aquaculturists saw the declining of capture fisheries and increasing demand as the key factors to drive the growth of aquaculture industry. However, the same reason has also seemingly become the limiting factor preventing it from thriving. The diversification of production systems leads to an underlying paradox: aquaculture is a possible solution, but also a contributing factor, to the collapse of fisheries stocks worldwide (Naylor et al., 2000). Not all of the types of aquaculture activity in Malaysia are a solution to the dwindling of the sustainability of marine capture fisheries.

Large fish meal and fish oil requirements for carnivorous finfish and prawns farming may further deplete wild fisheries stocks (Huntington and Hasan, 2009). Although many of the farmed carnivorous finfish are less commonly consumed among Malaysians, these are high value fish (e.g. groupers and snappers) produced for export market. Farmed prawn, on the other hand, is widely consumed in all three geographical locations. Malaysian aquaculture still largely depends upon "trash fish" due to their availability and low cost, characteristics which are considered by farmers to outweigh their poor growth and environmental performance (Huntington and Hasan, 2009). However, it is evident that the sustainability of "trash fish" as fish food is not guaranteed, since aquaculturists in current study claimed that the amount of trash fish was declining. The decline of trash fish maybe attributed to climate change as well as fierce competition as more farmers join the industry. Other herbivorous aquaculture species have low requirement for fishmeal and fish-oil in their diets, making them net producers of protein and therefore more sustainable options (Huntington and Hasan, 2009). This group includes grass carps, common carps and other cyprinids. Most of the fish that fall in this group are from freshwater origin. Unfortunately, these freshwater fish are not a popular option among Malaysian (Chapter 3). Wholesalers suggested that Malaysians are wary of consuming these fish because the flesh of these fish often carries a "muddy" flavour. They also suggested that consumers are likely to have negative perceptions towards farmed products. These negative perceptions could arise from poor consumption experience in the past (e.g. having bought fish with strong muddy flavour), bad press coverage or just irrational prejudice.

Threats to the validity of semi-qualitative interview included the use of researcher's preconceived leading questions. It was also significantly dependent on the skill of the interviewer. On top of that, because interviews were spoken in four languages and dialects (i.e. Malay, English, Chinese Mandarin and Chinese Cantonese), comparability could be reduced as sequencing and wording would be different in each interview of different languages. Considering the spontaneous nature of conversational interviewing and the complexity of language in use it was not possible to fully avoid these challenges. However, these potential drawbacks were compensated by the fact that interviews allowed participants to develop their own coherence and produce a richness and depth to data. Furthermore, by adopting a participatory approach in which the prime data were co-created and evaluated increases internal validity. Social desirability bias is particularly problematic for face to face interviews, and telephone interview is no exception. With this method interviewees may say what they think the interviewer wants to hear or the opposite of what they think they want to hear (Newton, 2010). Whenever individuals are questioned, even under oath in court, it cannot be certain they have told the truth (Newton, 2010). The researcher's concerns here were addressed by using checks and probes where there were doubts. It was the responsibility of the researcher, as with the barrister, to pull evidence from the data which when interpreted sounds convincing, credible and reliable (Newton, 2010).

5.5 CONCLUSION

It is apparent from previous studies (Chapter 2 and 3) that the fish consumption pattern of Malaysian cannot be sustained in a long run. As the most important animal protein source, many efforts are beginning to be put into the expansion of aquaculture industry. As much as the decline of capture fishery resources being recognised as a good opportunity for the growth and expansion of the industry, the question of whether this new emerging industry can alleviate wild fish stock remains unanswered. The diversity of production systems leads to an underlying paradox: aquaculture is a possible solution, but also a contributing factor, to the collapse of fisheries stocks worldwide. The issues raised by DoFM in 2009 are still largely unsolved today. Current market research has raised many challenges that were not previously mentioned by DoFM. There are still many adaptive and technical challenges that this new industry has to overcome, one of it being consumer resistance. Malaysian has high affinity for wild captured marine fish while certain farmed fish that have lower environmental impact are less preferred and underutilised. A consumer-focused approach to influence sustainable consumption is necessary. It is important to understand the current perceptions the public has towards the consumption of farmed fish before further sustainable expansion plans can be made. Results from current study are strongly suggestive of poor consumer perception likely to be a result of prejudice and/or lack of integrity of farmed products. Consumers' perception towards farmed fish warrants a further investigation and gathered responses from market experts helped form the fundamental issues to be discussed and assessed in the anticipated consumer study (Chapter 5).

CHAPTER 6: FISH PURCHASING BEHAVIOURS: PERCEPTION OF FARMED FISH VERSUS SCIENTIFIC EVIDENCE

6.1 INTRODUCTION

The worldwide consumption of fish has significantly increased during the last few decades, mainly due to the perceived image of fish as healthy food among consumers, the rapidly increasing global population and higher living standards as a result of booming economy (Cahu et al., 2004). This surge in demand has led to overfishing and triggered the onset of depletion of wild fish stocks (FAO, 2016). There is an urgent need to adopt more sustainable fisheries management to restore marine biodiversity and safeguard the contribution of fisheries to food security (FAO, 2016). Malaysia is of no exception. A review into Malaysian fish consumption habit (Chapter 3) has shown that Malaysian has high affinity for wild captured marine fish while certain farmed fish that have lower environmental impact are less preferred and underutilised. As the most important animal protein source, many efforts are beginning to be put into the expansion of aquaculture industry. However, aquaculture in Malaysia is still far from its full potential development. Interviews with local industry experts (Chapter 4) has found that the development of aquaculture is dampened by many adaptive and technical challenges, and more importantly the less positive perceptions consumer have for fish from aquaculture that is not officially acknowledged and studied.

Social science studies of aquaculture have generated increasing interest in recent years. Most of this research has focused on consumer attitudes towards aquaculture products (Verbeke et al., 2005; Verbeke and Vackier 2005; Verbeke et al., 2007; Vanhonacker et al., 2011; Hall and Amberg, 2013; Schlag and Ystgaard, 2013; Claret et al., 2014) and are focused on the main consumer markets of United States of America and European Union. The consumer's perception of fish as a healthy part of the human diet was consistently confirmed while there is gap between scientific evidence and consumer perceptions for the health character and nutritional value of fish (Verbeke et al., 2007). Knowledge about the fish and aquaculture practices is important in consumer selection of wild-caught versus farmed fish (Verbeke et al., 2007), especially if there is a concern over the adverse effects bad aquaculture practices can possibly bring. The detection of prohibited antibiotic residues in aquaculture products exported to the United States, particularly shrimp from China and the South East Asian region (including Malaysia) (FDA, 2016), may have fuelled consumers' prejudice against farmed fish products. On the contrary, some European consumers perceived farmed fish as less polluted by anthropogenic pollutants and heavy metals when compared to wild fish (Claret et al., 2014).

It is apparent that the current Malaysian fish consumption pattern which consists of predominantly farmed fish cannot be sustained in a long run, hence, a consumer-focused approach to influence sustainable consumption is necessary. Social science information can improve acceptance and promotion of aquaculture products through understanding consumer attitudes. Malaysian consumer beliefs and attitudes about cultured products have not yet been systematically examined. Social sciences are useful in gauging consumer attitudes toward products and in designing marketing campaigns for new or underutilised products. It is useful to know the depth, breadth, and dimensions of consumer perceptions, regardless of whether they are judged rational by producers or scientists. A recent interview with local industry experts that are vastly exposed to market demands and consumers' behaviours (Chapter 4) has provided important prerequisite information to formulate the following consumer survey. The major goal of current study is to examine consumers' fish purchasing behaviours and their perceptions of farm-raised fish and shellfish and to ultimately develop correlations among all three sectors: wholesalers, aquaculturists and consumers. It aims at identifying any disparities between consumer perception and scientific facts. The results provides valuable insights for further research, future public debates and policy making, all of which are useful for the development of aquaculture industry.

6.2 METHODS

6.2.1 Study Subjects

The study subjects consisted of adults of both genders who reside in Klang Valley and Selangor. All the subjects were selected based on a purposive sampling technique. The inclusion criteria of the subjects were (1) Malaysian and Malay or Chinese or Indian ethnicity; (2) aged between 18 to 60 years; (3) healthy and had no known illnesses; (4) able to give informed consent. All respondents, regardless of gender, must be the main responsible person for food purchasing within their household. Exclusion criteria were adults who have recently changed their dietary pattern and those practising special diet e.g. vegetarianism.

6.2.2 Study Design

The survey data were collected with questionnaire over a five-month period i.e. October 2015 to February 2016. Subjects were randomly recruited via street-intercept in selected areas (i.e. shopping streets, at supermarkets and at wet markets) within Klang Valley and Selangor. Subjects were approached for screening and were informed about the study. A verbal consent was sought before being interviewed using a questionnaire. In total, 310 questionnaires were collected. Of these, 76% (n=250) were classified as 'complete' and 24% (n=60) were classified as 'incomplete or unreliable'. The majority of questionnaires that were classified as 'incomplete or unreliable' (n=54) were excluded from the dataset because part of the responses given were self-contradictory and therefore not credible. Of those included in the analysis (n=250), 188 were women (75.2%) and 62 were men (24.8%). This gender distribution reflected the criterion that each respondent was the main person responsible for food purchasing within the household. The sample covered a wide range of consumers in terms of sociodemographic characteristics such as education, income and educational background (Table 33).

Table 33: Consumers' characteristics (%, n=250)

Characteristics	Proportion %	Total Sample (n=250)
Gender		
Male	24.8	62
Female	75.2	188
Age (years)		
18 – 29	14.0	35
30 – 39	22.4	56
40 – 49	27.6	69
50 – 59	22.8	57
60 – 69	11.2	28
≥70	1.2	3
Geographical Location		
Urban	50.4	126
Coastal	24.8	62
Rural	24.8	62
Ethnicity		
Malay	57.6	144
Chinese	29.2	73
Indian	13.2	33
Family Size		
1 or 2 persons	8.0	20
3 or 4 persons	33.6	84
5 or more persons	50.8	127
Highest Level of Education		
Completed Primary Education	16.0	40
Completed Secondary Education	36.4	91
Certificate/Diploma	29.6	74
Bachelor's Degree	10.8	27
Postgraduate Degree	6.0	15

Monthly Median Per Capita Income		
RM 500 or below	20.8	52
RM 501 – RM 1000	28.0	70
RM 1001 – RM 2000	28.0	70
RM 2001 – RM 3000	10.4	26
RM 3000 and above	3.2	8

The age group distribution of respondents was approximately normal. Half (50.4%) of the respondents resided in the urban area while their counterpart was equally distributed in rural (24.8%) and coastal (24.8%) area (Table 33). Most of the respondents lived in a household of more than 3 persons, with a large fraction (50.8%) living in a relatively big household of 5 members or more (Table 33). A vast majority (82.8%) of them received a minimum of 12 years of formal education (Table 33). The monthly median per capita income demonstrated a fairly right-skewed distribution, indicating that there were more people receiving low incomes than high incomes.

6.2.3 Development of Questionnaire

There were 6 major components in the questionnaire (Appendix L):

i. Items that assess farmed fish and total fish consumption frequency

The attempt to assess farmed fish consumption frequency proved tricky to carry out because no formal consensus is available. First, a fish availability survey was conducted. The names of fish species sold at various grocers, markets and restaurants were recorded. A comprehensive list of fish species commonly available and consumed was generated (Table 34). To select predominantly farmed species from the list, assumption has to be made based on analysis of data of capture fishery landing and seedling hatchery. Aquaculture consultant, fish suppliers and fishmongers were consulted to confirm that the selected list of farmed fish species was appropriate.

Table 34: List of Farmed Fish Species Commonly Available in Klang Valley

Local Name	**English Name**	**Latin name**
Siakap	Seabass/ Barramundi	Lates calcarifer
Tilapia	Tilapia	Oreochromis spp.
Patin	Silver Catfish	Barbonymus gonionotus
Keli	Catfish	Clarias batrachus

Salmon	Salmon	Salmo salar
Dory	Dory	Pangasius sutchi
Bawal Emas	Golden Pomfret	Trachinotus Ovatus
Kerapu	Grouper	Epinephelinae spp.
Jelawat	Hoven's Carp	Leptobarbus hoevenii
Kap/Tongsan/ Rohu	Common Carps	Cyprinus carpio
Jenahak	Snapper	Lutjanidae spp.
Toman	Snakehead	Channidae spp.
Lampan	Java Barb	Barbonymus gonionotus
Udang Putih	Whiteleg Prawn	Penaeus vannamei
Udang Harimau	Tiger Prawn	Penaeus monodon
Udang Galah	Freshwater Scampi	Macrobrachium rosenbergii
Siput/ Kupang	Mussels	Perna canaliculus
Kerang	Blood Cockles	Anadara granosa

Fish consumption behaviour was a self-reported measure. The respondents were asked through two questions how often they eat fish both at home and out of home; then the responses were summated in order to create one final variable, namely, total fish consumption. Frequency scale had 6 points, which were “seldom/never”, “2-5 times every 6 months”, “1-3 times a month”, “1-2 times a week”, “3-5 times a week” and “more than 5 times a week”. Further on, with the same scale, the respondents were asked to report how frequently they consume each of the farmed species as listed.

ii. Items that assess determinants at point of purchase

There were 9 items that assess influences of determinants at point of purchase, i.e. freshness, price, nutritional value, familiarity, cooking plan, sustainability, information of product origin, level of contaminants, presence of “muddy” smell. A 4-point Likert scale was used: range from “no influence” to “extreme influence”. A neutral response category was not included, which forced respondents to think and make up their mind about the proposed statements.

iii. Items that assess motives to eat fish

There were 9 items that assess motives that drive fish purchase and consumption, i.e. personal liking, family member's liking, advice of health professionals, cheap price, family habit, for a varied diet, easiness to prepare and customs and traditions. A 4-point Likert scale was used: range from "no influence" to "extreme influence". A neutral response category was not included, which forced respondents to think and make up their mind about the proposed statements.

iv. Items that assess barriers to consumption

There were 13 items that assess level of influences of barriers to fish purchase and consumption. Most of the barriers were the opposite statements of motives, i.e. personal disliking, family member's disliking, perceived unhealthiness of some fish, advice of health professional to reduce consumption of certain fish and expensive price. Other barriers included were the lack of experience in judging freshness, cleaning and cooking of fish, unpleasant smell when cooking, lower satiety compared to meat, abundance of bone, inconsistent supply of fresh produce and limited choices. A 4-point Likert scale was used: range from "no influence" to "extreme influence". A neutral response category was not included, which forced respondents to think and make up their mind about the proposed statements.

v. Items that assess perception of farmed versus wild fish

Respondents were first asked if they had any special preference for wild or farmed fish and whether they have knowingly purchased farmed fish before. Perceptions of farmed versus wild fish on 12 attributes were assessed. The attributes were freshness, quality, smell, taste, texture, availability throughout the year, price stability throughout the year, state of being "premium", value for money, health benefits, contaminant content and lastly sustainability. Respondents were required to answer whether fish of which wild or farmed origin was superior in each of the attributes. Two other response categories, i.e. "no difference" and "don't know", were included to better segregate the respondents' standpoints and avoid forced choice bias.

vi. Items that assess objective and subjective knowledge about fish

Objective and subjective knowledge about fish were assessed with 9 items. Subjective knowledge about fish was measured by three items: (1) "My friends consider me as an expert on fish"; (2) "I have a lot of knowledge of how to prepare fish for dinner"; and (3) "I have a lot of knowledge how to evaluate the quality of fish". Next, consumer's level of objective knowledge about fish origins and health benefits was measured with 6 statements that are either true or false. It was assumed that those statements should be common knowledge among at least half of the population. Of the 6 statements, a total of 3 statements were designed to assess the depth of understanding of fish and its fatty acids content. One of the statements was false: "Fish is the largest contributor of saturated fat in our diet when compared to meat and poultry." (fish but meat and poultry is) and two statements were true: "Fish is a source of omega-3 fatty acids"; and "The general nutritional difference between cold water and warm water fish is their fatty acid composition". For all the 9 statements, a binary scale "true"/"false" was used. A "don't know" response category was included in the options, which avoid forcing respondents to make wild guesses.

6.2.4 Statistical Analysis

Data were analysed using SPSS 22.0 (SPSS Inc., Chicago, IL, USA). Mean scores and standard deviations on 4-point scales, as well as frequency distributions, are presented in table format. Non-parametric bivariate analyses through correlation and comparison of mean scores, i.e. Wilcoxon–Mann–Whitney test and analysis of variance F-tests with Dunnett T-3 post hoc comparison of mean scores, were used to detect differences in frequency of consumption and perceptions between different sociodemographic and behavioural consumer groups. The consumers' perceptions of wild against farmed fish were compared to the results of interviews with wholesalers and aquaculturists in Chapter 4, and then subsequently checked against scientific evidence and grey literature.

The most frequently used measure of reliability is internal consistency, which is applied to the consistency among the variables in a summated scale. The underlying principle for internal consistency is that, the individual items or indicators of the scale should all be measuring the same construct and thus be highly inter-correlated (Tavakol and Dennick, 2011). In this study, Cronbach's coefficient alpha was used to test the reliability of the multiple items that used 4-point Likert scale. From the analysis, the standardised item (alpha) for these variables ranged from 0.859 to 0.882. The alpha scores for each factor were satisfactory as the Nunnally's (1978) guideline of a minimum alpha value of 0.5 for explanatory research was met. Nonetheless, Peter (1979) suggested that reliability levels of less than 0.5 might be acceptable in marketing research and argued that Nunnally's guideline should not be accepted as an absolute standard in marketing research.

6.3 RESULTS

6.3.1 Frequency of Total Fish Consumption

Total fish consumption frequency included in the analyses is the summative frequencies of total fish consumption and farmed fish consumption, at home and out of home. In the sample, 61.2% of the respondents consumed fish more than 3 times a week ('heavy users'); 33.2% of the respondents consumed fish less than twice a week but at least once a month ('moderate users') whereas only 5.6% consumed fish less than once a month ('light user') (Table 35).

Table 35: Prevalence of different types of fish consumers across different geographical locations

Types of fish consumers	**Geographical Location (%)**		
	Urban	**Coastal**	**Rural**
Heavy users	41.3	80.6	82.3
Moderate users	47.6	19.4	17.7
Light user	11.1	0.0	0.0

There were twice as many heavy users in rural and coastal as in urban. The urbanites had scored significantly lower ($p<0.05$) in terms of total fish consumption frequency. Generally, the Malays had highest total fish consumption score, but the differences were not significant. The trends observed here are consistent with the findings of FFQ in Chapter 2 which indicates good comparability. It was found that fish were consumed significantly more frequently at home than out of home ($p<0.001$). No significant difference was found across age groups and educational background.

6.3.2 Preferences and Prevalence of Farmed Fish Consumption

When asked about their preferences for fish origin, more than half of the urbanites (58.7%) reported no special preference while a majority of the coastal (67.7%) and rural dwellers (58.1%) preferred wild fish (Table 36). When asked whether they have purchased any type and species of farmed products in the past, 44.6% of total respondents answered "yes", with the highest prevalence noticed in rural (62.9%) (Table 37). It is worth highlighting that a considerable amount of urban respondents (42.4%) admitted that they were unsure if they have purchased any farmed fish and/or fish before (Table 37).

Table 36: Fish origin preference across different geographical locations

Do you prefer wild or farmed fish?	Total (n=250) %	Urban (n=124) %	Rural (n=62) %	Coastal (n=62) %
No special preference	46.0	58.7	38.7	27.4
Wild	46.4	30.2	58.1	67.7
Farmed	7.6	11.1	3.2	4.8

Table 37: Self-reported past purchase of farmed fish and/or fish across different geographical location

Have you ever purchased farmed fish and/or fish?	Total (n=250) %	Urban (n=124) %	Rural (n=62) %	Coastal (n=62) %
Yes	44.6	35.2	62.9	45.2
No	29.3	22.4	29.0	43.5
Not sure/ Don't know	26.1	42.4	8.1	11.3

As previous work have suggested that consumers generally lack knowledge of fish origin (Chapter 4), a predefined list of farmed fish species was used to assess consumption frequency of farmed fish. It was found that 62% (n=155) of the total respondents consumed at least one species of listed farmed fish at least once a week, with the trend showing highest prevalence in the rural and least in the urban. Frequency of farmed fish consumption was found to be significantly positively correlated to total fish consumption (Spearman's $r=0.352$; $p<0.00$). A stark finding in this study was that 63 out of the total of 73 respondents who self-proclaimed to be a non-consumer of farmed fish have ironically reported regular purchase of Vannamei prawn at least once a month. A majority of these respondents (81.0%) who regularly purchased farmed prawns unknowingly were urbanites.

6.3.3 Determinants at Point of Purchase

Generally, respondents regarded freshness, judged by visual and olfactory appeals, as the most influential factor in determining which type of fish and/or fish to buy whereas product origin and sustainability were the least important factors to consider at the point of purchase (Table 38).

Overall, the urbanites rated lower scores for all factors compared to their counterparts, except for three factors, i.e. chemical and heavy metal residues, product origin and sustainability (Table 38), which may suggest that the urbanites were more informed of the aforementioned factors. A factorial ANOVA to compare the main effects of ethnicity and geographical location and the interaction effects between the two factors on the scores of each of the determinants of point of purchase found no significant difference in any of these relationships.

6.3.4 Potential Factors and Barriers Influencing Decision to Buy Fish

Perception of fish as healthy food was rated as the most important factor that encouraged the purchase of fish (Table 39). Individual and family preferences were also influential (Table 39). The least influential motivating factor was the cheap price of fish (Table 39). Generally, the urbanites and the Chinese had lower scores across all motivating factors when compared to their counterparts (Table 39). A factorial ANOVA to compare the main effects of ethnicity and geographical location and the interaction effect between the two factors on the scores of each of the motivating factors of fish purchase found no significant differences in these relationships.

Lack of persistency of fresh produce supply was rated as the most important barrier that demotivates purchase of fish (Table 40). Difficulty to judge freshness and expensive price tags were also similarly important (Table 40). Consistently, the urbanites and the Chinese had higher scores across all demotivating barriers to consume fish when compared to their counterparts (Table 40). It was interesting to note that urbanites and Chinese had median scoring tendency and consistently avoided extreme options when confronted with questions using Likert scales, suggesting a median response bias. A factorial ANOVA to compare the main effects of ethnicity and geographical location and the interaction effect between the two factors on the scores of each of demotivating factors of fish purchase found no significant differences between any factors.

Table 38: Mean Likert-scale scores and standard deviations of determinant factors at point of purchase across different ethnicities & geographical locations

How much these factors influence your decision on choosing which type of fish/fish to buy?	**Total (n=250) Mean ±SD**	**Urban (n=124) Mean ±SD**			**Rural (n=62) Mean ±SD**			**Coastal (n=62) Mean ±SD**		
		Malay	**Chinese**	**Indian**	**Malay**	**Chinese**	**Indian**	**Malay**	**Chinese**	**Indian**
Looks and smell fresh	3.32±0.94	3.39±0.93	2.70±1.21	3.20±0.63	3.55±0.75	3.00+1.73	3.63±0.52	3.50±0.68	3.01±1.02	3.56±0.53
Is the type I am familiar with	3.08±0.93	3.25±0.65	2.44±1.15	3.10±0.74	3.26±0.82	2.33±1.16	2.88±0.99	3.26±0.69	2.00±0.52	3.67±0.50
Has no muddy smell	2.99±1.09	3.28±0.88	2.64±1.25	3.00±0.67	2.85±1.22	2.67±1.53	3.00±0.93	3.10±1.02	3.00±1.64	3.44±1.01
Is affordably priced	2.98±0.98	3.33±0.89	2.47±1.14	2.80±0.92	3.28±0.80	2.67±1.53	2.63±0.74	3.14±0.86	3.00±1.32	3.22±0.44
Has higher nutritional value	2.96±0.96	3.11±0.95	2.50±1.11	2.60±0.70	3.32±0.84	1.67±1.16	3.00±0.76	3.08±0.80	2.10±0.97	3.33±0.71
Is what I have pre-planned to cook	2.85±1.00	3.11±0.85	2.38±1.13	2.50±0.85	3.21±0.75	1.21±0.32	2.75±0.46	3.00±0.97	3.00±1.31	3.22±0.97
Is free of chemical and heavy metals	2.53±1.17	3.00±0.96	2.45±1.17	3.20±0.63	2.28±1.21	1.67±1.16	2.25±1.39	2.24±1.14	1.77±0.60	2.44±1.42
Has product origin information	2.30±1.11	2.67±1.15	2.25±1.13	2.30±0.82	2.06±1.09	1.12±0.27	2.38±1.19	2.38±1.14	1.89±0.54	2.33±1.32
Is sustainably produced	2.07±1.06	2.64±1.07	2.19±1.11	2.60±0.70	1.72±0.99	1.10±0.20	2.13±1.25	1.76±0.92	2.00±1.01	2.44±1.24

Footnote: The extent of influence of each factors was indicated using a scale of 0 (no influence), 1 (slight influence), 2 (moderate influence), and 3 (extreme influence).

Table 39: Mean Likert-scale scores and standard deviations of motivating factors of fish purchase across different ethnic groups & geographical locations

I buy fish and/or fish because . . .	**Total (n=250) Mean ±SD**	**Urban (n=124) Mean ±SD**			**Rural (n=62) Mean ±SD**			**Coastal (n=62) Mean ±SD**		
		Malay	**Chinese**	**Indian**	**Malay**	**Chinese**	**Indian**	**Malay**	**Chinese**	**Indian**
It is a healthy food	2.96±1.01	2.85±0.96	2.37±1.18	2.78±1.09	3.33±0.84	2.60±1.14	3.50±0.54	3.15±0.93	3.50±0.71	3.56±0.53
I like to eat	2.81±1.08	2.79±1.08	2.08±1.12	2.11±1.05	3.14±0.89	2.60±1.14	3.50±0.76	3.28±0.85	3.00±1.41	3.22±0.67
Some of my family members like to eat	2.80±1.03	2.85±1.01	2.10±1.09	2.67±1.00	3.09±0.75	2.20±1.30	3.25±1.04	3.30±0.75	2.50±2.12	3.00±1.00
We are used to eating it regularly	2.77±1.10	2.79±1.13	1.98±1.06	2.22±0.83	3.28±0.80	3.60±0.89	2.88±0.84	3.32±0.73	2.50±2.12	2.89±0.93
I'd like to have a variety in my diet	2.76±1.04	2.74±0.97	2.11±1.10	2.44±0.88	3.16±1.02	2.40±1.34	3.25±0.46	3.11±0.89	2.50±0.71	2.44±0.88
It is easy to prepare	2.76±1.08	2.77±0.99	1.98±1.12	2.56±1.01	3.28±0.91	2.20±0.84	2.75±0.89	3.28±0.80	2.00±1.41	3.11±0.93
It is a must-have during family meal or gathering	2.60±1.15	2.44±1.12	2.11±1.18	2.78±1.09	2.86±1.17	3.60±0.55	3.13±0.84	2.91±1.06	2.50±1.12	2.78±1.20
Health professionals advised to eat more	2.36±1.10	2.36±0.96	2.16±1.11	2.44±1.01	2.65±1.11	1.60±1.34	2.63±1.06	2.32±1.20	2.50±2.12	2.11±1.17
It is cheap	2.20±1.08	2.46±0.94	1.76±0.95	2.33±0.71	2.44±1.24	1.00±0.00	2.00±1.20	2.55±1.08	1.00±0.00	1.78±0.83

Footnote: The extent of influence of each factors was indicated using a scale of 0 (no influence), 1 (slight influence), 2 (moderate influence), and 3 (extreme influence).

Table 40: Mean Likert-scale scores and standard deviations of demotivating factors of fish purchase across different ethnic groups & geographical locations

I do not buy fish and/or fish because . . .	Total (n=250) Mean ±SD	Urban (n=124) Mean ±SD			Rural (n=62) Mean ±SD			Coastal (n=62) Mean ±SD		
		Malay	Chinese	Indian	Malay	Chinese	Indian	Malay	Chinese	Indian
The supply of fresh produce is not persistent	2.24±1.03	2.54±0.90	2.47±1.22	2.10±0.74	2.04±0.89	2.00±1.41	2.50±1.07	1.82±0.91	1.00±0.00	2.22±1.09
It is difficult to judge the freshness	2.23±1.00	2.40±1.01	2.23±1.07	2.40±1.08	2.26±0.95	1.40±0.89	2.00±1.00	2.27±0.97	1.00±0.00	2.22±0.97
It is expensive	2.21±1.03	2.50±0.99	2.28±1.11	2.30±0.95	2.13±0.98	1.60±0.89	2.29±0.76	2.08±0.98	2.50±0.71	1.56±1.13
Some fish and/or fish are not healthy	2.05±1.05	2.33±1.00	2.32±1.12	2.40±0.97	1.80±0.98	1.20±0.45	1.00±0.00	1.82±0.91	2.50±1.12	1.78±1.09
The choices are limited	2.04±1.00	2.37±1.04	2.26±1.13	1.9±0.88	1.91±0.99	1.20±0.45	1.88±0.84	1.86±0.91	1.50±0.71	1.89±0.89
Health professionals advised to eat less of some fish and/or fish	1.98±1.06	2.25±1.03	2.17±1.14	2.30±1.06	1.93±1.06	1.00±0.00	1.29±0.49	1.86±0.98	1.00±0.00	1.22±0.44
Some of my family members do not like to eat	1.88±1.05	2.20±1.07	1.96±0.98	1.70±1.06	1.78±1.09	1.80±1.10	1.43±1.13	1.71±0.89	2.50±2.12	1.22±0.67
The smell when cooking is unpleasant	1.86±1.05	2.00±0.93	2.30±1.25	2.20±1.03	1.67±0.97	1.00±0.00	1.86±1.22	1.57±0.91	2.50±2.12	1.11±0.33
It is difficult to clean	1.85±0.98	2.15±0.92	2.25±1.21	2.00±0.82	1.57±0.75	1.00±0.00	1.71±0.76	1.51±0.85	1.00±0.00	1.56±0.88
It is difficult to remove bones from fish	1.83±1.00	2.25±1.06	2.17±1.19	2.00±0.94	1.39±0.71	2.40±1.34	1.29±0.76	1.55±0.82	1.50±0.71	1.11±0.33
I do not like to eat	1.79±1.01	2.00±1.06	1.89±1.05	2.00±1.05	1.48±0.86	1.80±1.10	1.14±0.38	1.96±1.00	2.00±1.41	1.44±0.88
It is difficult to cook	1.73±0.96	2.00±0.91	2.17±1.21	2.00±1.01	1.46±0.78	1.00±0.00	1.57±0.79	1.39±0.76	1.00±0.00	1.11±0.33
Unlike other meat, fish and/or fish is not filling after eating	1.59±0.87	1.95±0.99	1.70±1.05	1.90±0.88	1.43±0.72	1.20±0.45	1.29±0.49	1.33±0.63	1.50±0.71	1.33±0.71

Footnote: The extent of influence of each factors was indicated using a scale of 0 (no influence), 1 (slight influence), 2 (moderate influence), and 3 (extreme influence).

6.3.5 Objective and Subjective Knowledge about Fish

The question that garnered highest percentage of correct responses (71.5%) was the one that assessed objective knowledge of fish as a source of omega-3 fatty acids (Table 41). When asked about their subjective knowledge of fish, about 75% of total respondents claimed that they did not know a lot about the harvesting of fish (Table 41), which indirectly explains the ranking of sustainability and origin of fish as least important factors to consider at point of purchase. More than half (53.6%) thought that they did not know a lot about how to evaluate the quality of fish (Table 41). Ironically, among those who claimed that they were regarded by their friends and family as somebody who knew a lot about fish (n=123), 71.5% answered 'yes' to the question "Fish is the source of dietary fibre"; 64.2% didn't know that the general nutritional difference between cold water and warm water fish is their fatty acid composition; and 64.2% thought that "fish is the largest contributor of saturated fat in our diet when compared to meat and poultry **".**

Table 41: Prevalence of different responses towards multiple statements assessing objective knowledge

Statements (*Answers*)	**Responses (n=250)**		
	True %	**False %**	**Don't know/ Don't understand %**
Fish is a source of dietary fibre. (*False*)	57.1	22.7	20.2
Mackerel and tuna are freshwater fish. (*False*)	15.1	60.4	24.5
The general nutritional difference between cold water and warm water fish is their fatty acid composition. (*True*)	27.9	8.1	64.0
Fish is the largest contributor of saturated fat in our diet when compared to meat and poultry. (*False*)	32.7	36.3	31.0
Salmon is a cold-water fish. (*True*)	52.4	12.2	35.4
Fish is a source of omega-3 fatty acids. (*True*)	71.5	4.1	24.4

6.3.6 General Perceptions of Farmed versus Wild Fish

The contrasting perceptions consumers had on different attributes of farmed and wild fish are presented in Table 42. Consumer perceptions for all relevant attributes were then compared with wholesalers' and aquaculturists' in the following subsections (6.3.7.1 to 6.3.7.5).

Table 42: Prevalence of consumers with different perceptions towards farmed versus wild fish

Attributes	Responses (n=250)			
	Farmed is better %	Wild is better %	No difference %	Don't know/ Don't understand %
Freshness	13.7	53.0	18.9	0.0
Quality	13.7	57.8	12.4	16.1
Smell	12.5	56.5	16.1	14.9
Taste	10.4	63.1	12.9	13.7
Texture	10.5	57.5	15.4	16.6
Availability throughout the year	31.6	19.8	16.6	32.0
Price stability throughout the year	30.9	15.0	21.1	32.9
High-class food	11.3	49.4	18.2	21.1
Value for money	16.9	39.5	23.4	20.2
Health benefits	8.9	54.7	19.4	17.0
Contaminant content	21.0	30.6	13.7	34.7
Sustainability	16.3	23.3	15.1	45.3

6.3.6.1 Taste and Texture

Consumers: Wild fish were thought to be more superior in terms of taste (63.1%) and texture (57.5%). When compared to their counterparts, it was found that significantly more coastal consumers ($p<0.05$) think that wild fish is superior in terms of taste.

Wholesalers: Compared to their wild counterparts, farmed fish were generally thought to have poorer taste (72.7%) and texture (63.6%). Open-ended responses suggested that farmed fish can smell bad and be muddy-tasting due to poor farming practices. However, it was suggested that farmed fish can have better texture and taste than their wild counterparts if raised with good welfare and were fed with high quality formulated feed. The farmed fish were regarded to have poorer texture due to the relatively smaller space for activities, thus less exercise for fish muscle.

Aquaculturists: Overall, aquaculturists did not think that farmed fish would necessarily have poorer texture and taste. While they agreed that farmed fish can be muddy-tasting due to poor farming practices, it was suggested that this problem only applies to freshwater fish whereas farmed prawns and marine species do not usually have muddy-taste. It was also mentioned that with formulated feed, farmed fish would have better texture and mouthfeel.

6.3.6.2 Quality and Freshness

Consumers: Wild fish were thought to be more superior in terms of freshness (53%). When compared to their counterparts, it was found that significantly more coastal consumers ($p<0.05$) think that wild fish is superior in terms of freshness.

Wholesalers: Overall, farmed fish were strongly regarded by wholesalers as more superior in terms of freshness (81.8%). Open-ended feedback suggested that farmed fish are thought to be fresher because they are usually caught alive before delivery. It was told that wild captured marine fish are usually a few days old when fishermen return to shore and its freshness depends on the distance they have to travel back to landing complex and more importantly whether the wild-captured fish are handled properly with suitable equipment.

Aquaculturists: Overall, similar to the trend seen amongst wholesalers' opinions, farmed fish were also regarded by aquaculturists as more superior in terms of freshness (62.2%). Some aquaculturists agreed that farmed fish are fresher because they are usually caught and chill-killed right before delivery. It was also claimed that wild captured marine fish usually takes a longer time to return to shore after killed but freshness of fish would also depends on whether the fishing vessels are well-equipped. One aquaculturist claimed that less-equipped fishermen often use preservatives e.g. formaldehyde to keep fish fresh for days as the total transit time takes about two weeks before the fish finally arrive in cities.

6.3.6.3 Availability and Price Stability

Consumers: Although one-third of the consumers thought farmed fish have better stock availability and price stability, an approximately equal amount of them on the other hand did not know or understand these two attributes.

Wholesalers: Overall, farmed fish were strongly regarded by wholesalers as more superior in terms of availability (90.9%) and price stability (81.8%). Open-ended feedback suggested that price stability is highly dependent on the consistency of supply. The yield of farmed fish can be better predicted and monitored; hence the prices of farmed fish are more stable.

Aquaculturists: Similar to the trend seen amongst wholesalers' opinions, farmed fish were also regarded by aquaculturists as more superior in terms of uniformity of size (73.0%). However, divided responses were seen in terms of price stability. In agreement to wholesalers' opinion, aquaculturists also suggested that the yield of farmed products is more predictable than that of wild-captured, however, it was highlighted that both means of production are also seasonal and heavily influenced by weather and climate change.

6.3.6.4 Health Benefits and Contaminant Content

Consumers: About half of the consumers thought that wild fish has more health benefits than farmed. For perception of contaminant content, there were as many consumers who thought farmed ones are more contaminated (30.6%) as those who reported that they "Don't know and/or understand" (34.7%).

Wholesalers: About half of the wholesalers (54.5%) thought that wild fish are more superior in terms of health benefits. Some wholesalers thought that the nutritional value of fish reflects the quality of fish food. It was thought that farmed fish had lower nutritional value because they were fed with "manmade and unnatural feed", and were treated with "drugs and injections", while wild-captured fish were more nutritious due to eating "natural food in their habitat" and were not treated with "drugs and injections". Farmed products were perceived as so inferior that one respondent claimed that he would go to jetty to buy wild-captured products for his family consumption. It is worth highlighted that some wholesalers stated that comparing wild-captured and farmed products in the Malaysian context are like comparing apples and oranges. Wholesalers had divided responses towards the contaminant content. The number of wholesalers was quite fairly distributed in all five response options (i.e. neutral and non-neutral) when asked to compare the level of contaminant between the wild and farmed fish. Open-ended feedbacks suggested that the level of contaminants is closely related to water quality of where the fish originated, regardless of whether the fish is wild-captured or farmed. However, while fishermen could not control the level of pollutants in marine water (especially offshore), some of the wholesalers believed that aquaculturists could monitor the level of pollutants in confined tanks or ponds. The wholesalers also claimed that if the farmed fish are fed with low quality feed (e.g. catfish being fed chicken intestines; pellets with chemical additives), the water quality will be largely affected.

Aquaculturists: Divided responses were seen in both health benefits and level of contaminant. Their open-ended feedbacks suggested that the nutritional value of fish reflects the quality of fish food. It was thought that wild fish had better nutritional value because they had access to "natural food in their habitat" while some aquaculturists thought that fish fed with formulated feed will have yield products with better nutritional value. Level of contaminants was also thought to be closely related to water quality of where the fish originated, regardless of whether the fish is wild-captured or farmed. However, aquaculturists felt that they have the advantage of being able to monitor the level of pollutants in confined tanks or ponds while fishermen could not control the level of pollutants in marine water (especially offshore). It was suggested that if the farmed fish are fed with low quality feed – "catfish being fed chicken intestines" and "pellets with chemical and drug additives", the water quality will be largely affected, especially so when the ponds are stagnant with a poor clean water circulation rate. Aquaculturists also suggested that the level of excretory waste in ponds may be more concentrated thus tainting the products with foul smell. One aquaculturist, who was based in Johor's fishing village – Kukup Island, confessed that she was sceptical of the side effect of the "numerous chemicals used in fish farming", so much so that she would not consume her own products but would instead buy wild captured fish from a trusted fisherman whom is her close friend for her family consumption.

6.3.6.5 Consumers' Appreciation

Generally, about half of the consumers regarded wild fish as a "high-class food". When compared to their counterparts, it was found that significantly more coastal respondents ($p<0.05$) regarded wild fish (75.8%) as a "high-class food", which was consistent with the suggestion of wholesalers and aquaculturists as discussed in previous chapter. Most of the wholesalers (72.7%) and aquaculturists (67.6%) perceived that consumers would regard farmed fish as low-value. However, it was also suggested that it is a result of negative image and perception on intensive agricultural farming in general.

6.4 DISCUSSION

The chapter has explored a breadth of issues with the main aim being investigating consumers' fish purchasing behaviours and their perceptions of farm-raised fish and shellfish. It was found that the majority of the consumer sample reported perceived differences between farmed versus wild fish. The consumers perceived farmed fish as inferior in terms of several quality-defining attributes, i.e. freshness, taste, texture, health benefits and contaminant content, when compared to the wild counterparts. As these consumers perceived health benefits and freshness as the most important factors for fish purchase and consumption, the low preference for farmed products could be attributed to their negative perceptions of the above-mentioned quality-defining attributes. When the perceptions of all three sectors – wholesalers, aquaculturists and consumers – were correlated, it was found that while most wholesalers and aquaculturists alleged that consumers were generally prejudiced against farmed products, the wholesalers themselves also perceived farmed products as poorer in some quality-defining organoleptic attributes. Aquaculturists on the other hand were more skewed to neutral responses and sounded somewhat defensive when asked to comment on the possible causes of perceived poorer quality of farmed products.

Wholesalers act as a bridge between the producers (fishermen and aquaculturists) and end users thus their account for the current market practice are credible to a certain extent. The poor practices in farming and wild harvesting as alleged by wholesalers are certainly worthy of further investigation. Alternatively, the negative biases on quality-defining organoleptic attributes among wholesaler may be a reflection of consumers' perception or a bias resulting from the knowledge of allegedly poor farming practices. Similar to the findings from Verbeke et al. (2007), the interviews with wholesalers and aquaculturists suggested that consumers' opinions and beliefs about farmed fish are mainly based on emotion rather than on awareness and factual knowledge of aquaculture. In fact, consumers scored poorly for objective knowledge of fish when surveyed. Current evolutions in aquaculture and forecasts will soon lead to growing interest and debates on the health, safety and sustainability issues related to farm versus wild fish, as have happened in the developed countries (Verbeke et al., 2007).

Organoleptic properties and nutritional value are two sets of characteristics that, together with freshness, consumers use to determine the quality of fish (Grigorakis, 2007). These characteristics are dependent on the chemical composition of the fish, which is in turn dependent on the inherent traits of the fish (e.g. species, sex), environmental variables (e.g. temperature, salinity) and feeding history (e.g. diet composition) (Grigorakis, 1999). In Europe many works on differentiation of wild and farmed fish has been done for authentication of Atlantic salmon products

(Aursand and Axelson, 2001; Aursand et al., 1994, 2000; Igarashi et al., 2002; Bell et al., 2001). However, it is important to note that there is no relevant authentication analysis being conducted in Malaysia and the surrounding region, mainly because the commonly consumed fish are either exclusively wild or exclusively farmed.

The following subsections discuss the possible differences between farmed and wild fish in terms of freshness, taste, texture, health benefits and contaminant content and any mismatch between consumer perception and scientific facts is identified.

6.4.1 "Farmed fish are not as fresh as the wild ones"

The determination of spoilage rates is an important measurement to evaluate the freshness of fish (Venugopal, 2005). Spoilage is indicative of post-harvest changes in fish and dictates the remaining shelf life of fish (Venugopal, 2005). The spoilage process starts as soon as the fish dies. There are three stages of spoilage, namely rigor mortis, autolysis and decomposition (New Zealand Institute of Chemistry, 2008). The two major proteins actively involved in muscle contraction, actin and myosin, combine in the presence of calcium ions to form actomyosin (New Zealand Institute of Chemistry, 2008). ATP then supplies the energy for contraction, and later also the energy for the removal of the calcium ions via a calcium pump (New Zealand Institute of Chemistry, 2008). This breaks the actomyosin complex, leaving the muscle ready for a further contraction (New Zealand Institute of Chemistry, 2008). On death, the circulatory system stops and the ATP levels drop; calcium ions leak, forming actomyosin (New Zealand Institute of Chemistry, 2008). However, because there is insufficient ATP for the calcium pump to operate, the actomyosin complex remains unbroken, rendering the muscle in a continual state of rigidness, known as rigor mortis (New Zealand Institute of Chemistry, 2008).

Meanwhile, the glycogen present in the muscle is anaerobically metabolised as the blood circulation stops and oxygen supply prevented. The glycogen is converted into lactic acid and the pH of the fish muscle falls (FAO, 2005). The formation of the lactic acid continues until the supply of glycogen is completely used up (FAO, 2005). Soon after rigor mortis is completed, muscle rigidness gradually reverses accompanied by an increase in pH, ending up in softening of muscle (FAO, 2005). This is followed by autolysis. Enzymes in the flesh and gut previously involved in metabolism now catalyse autolytic reactions, in which various compounds decompose (New Zealand Institute of Chemistry, 2008). Autolysis creates favourable conditions for the growth of bacteria (New Zealand Institute of Chemistry, 2008). In a living fish, bacteria are present in the gut and skin, but the flesh, which they are prevented from entering, remains sterile (New Zealand Institute of Chemistry, 2008).

Once autolysis begins, however, the bacteria are able to enter the flesh, whereupon they multiply rapidly and decompose the muscle (New Zealand Institute of Chemistry, 2008).

The fundamentals in fish biology, chemical composition of fish and *post mortem* changes, with a view to explaining the rationale for optimal catch handling procedures and obtaining maximum shelf life was discussed in the FAO Fisheries technical paper 348 written by Huss (1995). Several factors contribute to spoilage of fish: temperature, physical damage and intrinsic factors. In a nutshell, small fish with low reserves of energy as a result of exhaustion and being kept at a high temperature will enter and pass through rigor very quickly (Stroud, 1969). On the other hand, large, rested, well-fed fish kept at a low temperature will take a very long time to enter and pass through rigor (Stroud, 1969). Stress in wild and farmed fish, which are very active before death, can affect the onset of rigor mortis (Borderías et al., 2011). If the fish is killed after muscle activity, its cells will contain more lactic acid from anaerobic respiration, so that adenosine triphosphate (ATP) synthesis is stopped and *rigor mortis* sets in sooner (Borderías et al., 2011). Intrinsic factors are species specific, rather than whether wild or farmed. Meanwhile, temperature and physical damage are highly dependent on human factors such as harvesting methods and post-harvesting processing and handling steps. These first processing steps of fish have slightly different practices for wild and for farmed fish.

Borderías et al. (2011) reviewed the primary processing steps of wild and farmed fish that are vital to maintain freshness of fish. They found that wild fish are harvested by a large variety of methods. It was noted that each method used involves various degrees of desperate struggle followed by a period of asphyxiation once the fish is on board. To control stress produced by these conditions, Borderías et al. (2011) thought it is necessary to control mainly the fishing method and time but highlighted the difficulty for practice change as the method used is often dictated by commercial considerations. Fish that have been trawled are subject to more stress from prolonged struggling in the net, and this stress has been shown to affect ice-storage quality because the onset of rigor mortis is faster when they are caught in a highly stressed state (Borderías et al., 2011). On top of that, Borderías et al. (2011) also found that trawled fish generally carry 10 to 100 times higher microbial loads than line-caught fish because of mud stirring contamination and gut contamination produced by the pressure of the fish in the net. They also pointed out that the fish could die of pressure and became bruised in prolonged hauling of net. As such, microorganisms could be introduced to the flesh, thus accelerating spoilage.

Borderías et al. (2011) also discussed the different handling steps of farmed fish. The ideal first operation for farmed fish as highlighted by Borderías et al. (2011) is to carefully separate fish from the main cages into smaller holding units without causing more stress than necessary. At this stage, the ideal density was cited as around 5 to 10 kg/m^3 until ready for collection. Next, Borderías et al. (2011) reviewed that starving the fish for as long as is necessary to ensure that gut contents are emptied because the digestive tract of the fish contains many bacteria that produce digestive enzymes capable of causing intense post-mortem autolysis, resulting in strong odours and flavours. Starvation is also very important to prevent faeces trailing from the anus, which is off-putting for consumers (Borderías et al., 2011). To kill the fish, Borderías et al. (2011) found that the method most commonly used by farmers is chill-killing i.e. to plunge the fish directly into iced water of which temperature is kept close to 0 ◦C at all depths. However, Borderías et al. (2011) quoted spiking (i.e. swift puncturing of the brain) as the best method. As the brain is destroyed, the drop in ATP is retarded immediately (the agent that prevents interlocking of thin and thick filaments) and so by preventing muscle activity, the onset of rigor mortis is effectively delayed as compared to a slower death, i.e. chill-killing (Borderías et al., 2011).

It is important that captured fish be rapidly cooled and handled carefully as soon as it is on board so that the microbial activity can be controlled, reduced or even retarded (Borderías et al., 2011; FAO and WHO, 2012). In the case of farmed fish, chill-killing fish maintains the cold chain. Capture fisheries on the other hand have to make sure the fish are held at 0^{o}C by proper icing immediately after catch to reduce spoilage. While big commercial fishing vessels are fitted with refrigeration systems, most traditional fishermen use ice box. In order to keep the freshness of fish, Malaysian fishermen and fish vendors tend to carelessly use formaldehyde as preservation agent. The education officer of Consumers Association of Penang, N.V. Subbarow, said fishermen who were out at sea for a longer stretch of about 10 days usually resorted to mixing formalin with ice to ensure the freshness of the fish (Tan et al., 2012). The president of Sabah Anglers Association, Datuk Wilfred Lingham, has urged the authorities to strictly monitor the sale and distribution of formaldehyde (formalin) in the market (Anon., 2015). According to Lingham, it can easily be bought in liquid form in shops near the central fish market. The reckless use of formalin has been confirmed in two Malaysia studies as researchers found unnatural levels of formalin in the fish tested (Noordiana et al., 2011; Siti Aminah et al., 2013). This illegal use of formalin is now a worldwide phenomenon as it is noted in many parts of the world (Chandralekha et al., 1992; Tunhun et al., 1996; Drastini and Widiasihl, 2009; Tang et al., 2009; Andrews, 2013).

To ensure the freshness of wild and farmed fish, both fishing industries share common aims in terms of stress reduction during harvest and maintenance of low temperature post-harvest. Fish farming does have certain advantages over capture fisheries in that the fish farmers can influence pre- and post-mortem biochemistry and freshness parameters by implementing specific operating procedures. Trawling and purse-seining, of which both require significant hauling efforts, are the main marine capture methods practised in Malaysia and in the rest of Southeast Asia; hence, wild fish that are available for local consumption can be generally assumed as having been more stressful and suffered more injuries (thereby increasing the rate of spoilage) than farmed fish during harvest. On top of that, because of the uncontrolled use of formalin to preserve wild fish among local fishermen, its risk to local consumers' health is unknown. As such, consumer's perception that wild fish are more superior in terms of freshness is unsubstantiated.

6.4.2 "The texture of farmed fish is poorer than the wild ones"

The properties of fish texture are not only species-specific but are also multifactorial. Because of the wide scope of the topic, only selected factors that can contribute to the comparison between wild and farmed fish are discussed. The many factors that influence textural characteristic of fish flesh can be broadly categorised to 1) muscle structure of fish flesh, 2) muscle cell biology and 3) the amount of physical exercise. According to Love (1997), the muscle structure of fish flesh may vary at different fishing locations, which may be influenced by geographical, seasonal, and feeding factors, post-mortem biochemical factors, and the postharvest filleting process. Nonetheless, the texture of fish is also determined by a number of intrinsic factors (such as species, compositions, and size) and post-mortem factors (glycolysis, rigor mortis, gaping of fish muscles, changes of toughness, skeletal attachment, and effect of temperature) (Dunajski, 1980). Frozen storage was found to affect the ultrastructure and texture of fish muscle (Herrero et al., 2005)

The published studies concerning the effect of swimming exercise on fish texture produced mixed results. Swimming exercise increased the flesh firmness in both Atlantic salmon and sea bream (Totland et al., 1987) and improved the texture of cultured sea bream by retarding postharvest softening (Tachibana et al*.,* 1988). Also, when swimming effort of brown trout increases, the quantity of dark muscles increases at moderate velocities and the quantity of white muscle increases at greater velocities (Davison and Goldspink, 1977). In fish, it is assumed that red muscles exhibit more elevated fat content than white muscles due to higher numbers of fat cells in the perimysium and higher numbers of lipid droplets within muscle fibres, thus causing textural differences between the two muscles (Listrat et al., 2016). On the contrary, there is increasing evidence that exercise prior to slaughter contributes to softening and gaping of fish flesh (Kiessling et al., 2004). On the other hand, Hochachka (1961) suggested that trained fish have a higher content of tissue buffers such as anserine and ability to tolerate higher content of lactic acid. Exercise conditioning also decreases the extent of lactic acid accumulation in stressed fish (Broughton and Goldspink, 1978). While some studies supported that stress affects texture of fish (Sigholt et al., 1997; Skjervold et al., 2001), other studies disagreed (Azam et al., 1989; Ostenfeld et al., 1995).

In terms of muscle cell biology, there are uncertainties regarding the underlying mechanisms and factors that contribute to the post-mortem softening of the flesh (Roth et al., 2006). Some attempts have been made to suggest that some mechanisms other than energy metabolism and rigor mortis are the source for accelerating the post-mortem tenderisation. The nutritional status of fish and the amount of stress and exercise encountered before death will have an effect on the levels of stored glycogen and consequently on the ultimate post mortem pH (Phillips et al., 2001). After death, when the anaerobic muscle cannot maintain its normal level of ATP, the muscle enters rigor mortis (Phillips et al., 2001). Post mortem glycolysis results in the accumulation of lactic acid which in turn lowers the pH of the muscle (Phillips et al., 2001). The post mortem reduction in the pH of fish muscle has an effect on the physical properties of the muscle. As the pH drops, the net surface charge on the muscle proteins is reduced, causing them to partially denature and lose some of their water-holding capacity (Huss, 1995). Loss of water has a detrimental effect on the texture of fish muscle and it has been shown by Love (1975) that there is an inverse relationship between muscle toughness and pH, unacceptable levels of toughness (and water-loss on cooking) occurring at lower pH levels.

The amount of lactic acid produced is related to the amount of stored glycogen in the living tissue. As have discussed earlier in section 6.4.1, well-rested, well-fed fish contain more glycogen than stressed and exhausted fish. Fish with excessive muscular glycogen tend to have a low ultimate pH and hence high drip loss and poor texture quality (Haard, 1992). Farmed fish are normally well-fed and sedentary compared to wild animals. In general, farmed fish tend to have a softer texture than free-living sources, e.g. red drum (Jahncke et al., 1988), Atlantic salmon (Farmer et al., 2000; Johnston et al., 2006) and sea bass (Periago et al., 2005; Fuentes et al., 2010). On contrary, Sveinsdóttir et al. (2009) found that farmed cod products were considerably different from wild cod, with more meaty texture sensorially. Another untrained panel found that the texture of farmed salmon was as acceptable as wild salmon, although both types of salmon differed in terms of texture when measure instrumentally (Farmer et al., 2000).

Dietary pattern has been found to have a profound effect on flesh texture. The expressible moisture of muscle tissue, the texture and certain sensory characteristics of sea bream (Sparus aurata) fillet from different feeding habitats have been evaluated by Orban et al. (1997). The fillets were from both intensive and extensive farming systems; the former were raised on artificial feed in tanks, the latter were bred and raised on a natural diet in brackish water lagoons. The sea bream raised on artificial feed had a higher fat content which produced higher fatness, juiciness and lower fibrousness measured both instrumentally and sensorially. In another study, two sea bass groups with different levels of fat intake showed differences in muscle fat and subsequently in organoleptic properties, with high fat seabass being significantly juicier and more tender (Lopparelli et al., 2004). Sensory fatness and juiciness have both been shown to positively correlate with fat content in tissue (Dunajski, 1980; Einen and Thomassen, 1998; Izquierdo et al., 2003; Grigorakis et al., 2004). However, extensive lipid differences were found to result in softening of the fillet (Andersen et al., 1997).

It is challenging to compare the results from different studies on texture quality because of the inconsistent correlation between instrumental analysis in raw fish and sensory analysis on cooked fish (Andersen et al., 1997; Bjørnevik et al., 2003). Nonetheless, differences between fish obtained from different systems reveal the general impact of the genetic makeup and life history of the fish in its texture quality. However, the differences in texture might be offset after undergoing storage. Alasalvar et al. (2002) reported that the texture of cultured and wild sea bream stored in ice decreased throughout the storage period, and the texture of both groups were not significantly different until after day 16 when the wild fish was significantly softer than the farmed fish. Not to be forgotten is the fact that preference for fish flesh texture is a subjective opinion. Aquaculturists do possess an advantage over fishermen since they can manipulate different stages of the rearing, feeding and processing steps wherever possible to deliver to consumers a designer fish with preferred textural quality. Hence, consumers' perception that wild fish has better texture than farmed fish is an unjustified belief.

6.4.3 "Farmed fish have poorer flavour and odour than the wild ones"

Flavour is the most important factor for consumer acceptance of fishery products (Haard, 1992). Flavour and odour are often associated with freshness (Rasmussen, 2001). This emphasises the importance of implementing correct first processing steps and subsequent storage of fish. The major cause of food spoilage is microbial growth and metabolism resulting in the formation of amines, sulphides, alcohols, aldehydes, ketones, and organic acids with unpleasant and unacceptable off-flavours (Gram and Dalgaard, 2002). For example, bacterial reduction of trimethylamine oxide to trimethylamine creates the typical `fishy' odour in fish (Rasmussen, 2001). Oxidative rancidity is also responsible for off-flavour episodes. When fish is improperly stored and packaged, the highly unsaturated fatty acids in fish can be oxidised by atmospheric oxygen and turn rancid (Rasmussen, 2001). However, the rate of rancidity of unsaturated fatty acids in fish may be reduced in the presence of antioxidant vitamins. Vitamin E supplements can be added to artificial fish diets in order to prevent lipid peroxidation and improve product conservation (Verbeke et al., 2007). Although prone to rancidity, unsaturated fatty acids are important precursors of volatile flavour compounds (Grigorakis, 2007). Characteristic aroma compounds (e.g. alcohols and carbonyls) for fresh fish are derived from specific polyunsaturated fatty acids as well as the specific lipoxygenase involved in hydroperoxide formation (Haard, 1992). Other taste active compound in fish includes free amino acids content that strongly affects the impression of taste in the mouth (Arechavala - Lopez et al., 2013).

Farmed and wild fish were found to differ in fatty acids and free amino acids (FAAs) profiles (Fuentes et al., 2010). The profile of volatile aroma compounds of wild fish contains a higher number of more "delicate" taste-contributing compounds. Alasalvar et al. (2005) has found that the content of aldehydes, ketones, aromatics, and terpenes were present in wild sea bream as compared to that of its cultured counterpart. Wild ayu differs from cultured ayu in having a sweet aroma, like watermelon (Suyama et al*.,* 1985). As wild fish tend to contain more eicosapentaenoic acid (EPA) than farmed fish, Josephson and Lindsay (1986) proposed that enzymatic action on EPA would yield hydroperoxides that undergo chain breakage to form these melonlike volatiles. On the other hand, some FAAs related to the characteristic flavour of fish, such as glutamic acid, aspartic acid, alanine, and glycine were more abundant in cultured sea bass (Fuentes et al., 2010). The differences found in the fatty acids and FAAs related to the organoleptic characteristic between farmed and wild fish as discussed above could cause variations in the flavour and aroma of fish, which in turn could influence consumers' perception depending on their origin (farmed or wild). However, sensorial indicators do not consistently provide a clear basis to separate farmed and wild sea fish (Arechavala - Lopez et al., 2013). Nonetheless, the selection of best fish flavour and aroma is a matter of opinion.

Diet may influence the aroma of fish. For example, consumption of certain marine algae containing dimethyl-ß-propiothetin by marine fish results in an off-odour caused by dimethylsulfide (Ackman et al., 1966, 1968 and 1972). Similarly, cultured fish can be affected by both pleasant and unpleasant aromas in the commercial feed. There are anecdotal reports that farmed salmon fed crustacean meal has better flavour than fish strictly fed commercial rations (Haard, 1992) whereas partial inclusion of soybean oil showed slight influences in organoleptic properties like stronger smell and taste in sea bream (Izquierdo et al., 2005). High levels of soybean oil in salmonid feed have been reported to a form of off-flavour called 'hatchery flavour' (Haard, 1992), but this effect was not statistically significant in the full substitution of fish oil with soybean oil in sea bass (Montero et al., 2005). Crude oil and other hydrocarbon contaminants in marine waters where off-shore exploitation of oil is intensive or in areas where large oil spills occur can also result in off-flavours in both farmed and wild marine fish (Martinsen et al*.,* 1992). This is caused by the accumulation of various watersoluble hydrocarbon compounds, where particularly the aromatic compounds are strong flavourants (Martinsen et al., 1992).

On the other hand, the question of whether the fish is from freshwater or saltwater seems to be more important in determining flavour differences than whether the fish is wild or farmed. It was found that the main differences in flavour occur between river and sea-caught salmon but not between wild and farmed salmon (Farmer et al., 2000). A sensorial evaluation conducted by Flos et al. (2002) has also found flavour differences among sea bream from three inland culture systems of varying intensiveness but no differences between them and wild equivalents. These sensorial differences may be attributable to the differences of microbiological quality of water as the aroma of the fish is heavily influenced by the presence of certain organisms and algae in the aquatic environment (Orban et al., 1997), and this is especially true for freshwater fish. The most common off-flavour compounds in freshwater fish, geosmin (GSM) and 2-methylisoborneol (2-MIB), are unique to fresh water and are produced and released from cyanobacteria species into the water (Smith et al., 2008). GSM and 2-MIB are lipophilic compounds which can bioaccumulate in lipid rich fish tissues (Robertson et al., 2006; Percival et al., 2008). It has been shown that the uptake route of these compounds is primarily via the gills (From and Hørlyck, 1984) and the bioaccumulation of these compounds leads to the presence of an undesirable but harmless earthy–musty taint in exposed organisms (Robertson et al., 2006; Percival et al., 2008).

In Malaysia, the most common fish cultured for local consumption are tilapia and catfish, both of which are freshwater fish. A vast majority of the freshwater fish are raised in mining pools and earthen ponds (DoFM, 2014). Unsurprisingly, Nurul Izzah et al. (2004) detected the presence of GSM and 2-MIB in tilapia caught in an ex-mining pool, river and lake in Selangor, Malaysia. The amounts of these two compounds varied; the more stagnant the water the higher the concentration (Nurul Izzah et al., 2000). Integrated farm system is common in Malaysia, especially among the small scale farmers and some big players (e.g. Federal Land Development Authority (FELDA)) (FAO, 2017b). Fish are farmed together with poultry and crop plantation under this system (FAO, 2017b). Nutrients from uneaten feed, manure and other wastes from chicken cages over-hanging the pond fertilise pond waters to produce natural food for the fish, and thus reduce commercial feed cost (Pimolrat et al., 2015). However, proper management of water exchange and fish to poultry ratios in these freshwater farms are essential to maintain water quality. The levels of GSM and 2-MIB increase as water quality deteriorates in stagnant water as a result of eutrophication which promotes cyanobacterial blooms (Gutierrez et al., 2013; Pimolrat et al., 2015).

Fish can be purged of taint compounds if transferred to GSM/2-MIB-free water but the process is much slower than the rate of uptake (Robertson et al., 2006). The off-flavours associated with GSM and 2-MIB are one of the most serious problems affecting commercial freshwater products since consumers are strongly averse to such flavours in fish products (Robertson et al., 2006; Robin et al., 2006; Gutierrez et al., 2013). Off-flavours in pond-raised catfish have been described as sewage, stale, muddy-musty, rancid, metallic, mouldy, weedy, and petroleum (Johnsen et al., 1987). The problem of earthy–musty taints in wild or farmed freshwater fish is a global one, with occurrences documented in commercial freshwater species (e.g. tilapia, catfish, trout, salmon and barramundi) of North America (Dionigi et al., 2000; Zimba and Grimm, 2003; Hurlburt et al., 2009); Europe (Robertson et al., 2006; Robin et al., 2006); Asia (Gutierrez et al., 2013; Pimolrat et al., 2015) and Australasia (Jones et al., 2013; Hathurusingha et al., 2016).

The types of farmed fish available locally in Malaysia are usually freshwater fish and are not as popular as wild captured marine fish (Chapter 3). As suggested earlier, the reason for low consumption might be due to the unique sensory characteristic which is different from marine fish. In 2001, Bakar et al. attempted to identify the difference in flavour profile between common freshwater and marine fish in Malaysia. Trained panellists were used to identify the flavour profile which consists of aroma, flavour and aftertaste of tilapia, Indian mackerel, small tuna and catfish. The earthy flavour characteristic was recognised in both the tilapia and catfish but not at all in the marine fish. In fact, it was the dominant character detected in tilapia and catfish. Fish oil aroma was identified as the strongest characteristic in Indian mackerel and small tuna. It is thus hypothesised that Malaysian consumers have strong preference for fish oil aroma that is typical of wild marine fish; and since tilapia and catfish are predominantly farmed, the perception that farmed fish has inferior flavour and aroma arises. Due to the negative image generated from the consumption of inferiorly farmed freshwater fish like tilapia and catfish, Malaysian consumers' perception that wild fish is more superior in terms of flavour and odour is understandable. Unknown to the consumers is the fact that most of the factors affecting the typical aroma of fish, e.g. the n-3 PUFA content of muscle, dietary pattern and water quality, can be manipulated by farmers and fish feed producer but are beyond control for wild fish.

6.4.4 "Farmed fish are less nutritious compared to the wild ones"

Fish is a nutritious food as it contains a wide array of nutrients essential for human health. In an advisory note prepared by Torry Research Station, the structure and main components of fish muscle in commercial fish were described and explained (Murray and Burt, 2001). It was stated that the amount of protein in fish varies a little from species to species, somewhere between 15 and 20%, and is roughly comparable to those of meat. Often undervalued parts of the fish, like the head, viscera, and back-bones make up 30-70% of fish and are especially high in micronutrients (e.g. iodine, vitamin D, and calcium) (Murray and Burt, 2001). Hence, small fish such as anchovies that are cooked and eaten whole in Malaysia contain micronutrients that are not typically obtained from consuming larger fish. Taking all species into account, the fat content of fish can vary very much more widely than the water, protein or mineral content; whilst the ratio of the highest to the lowest value of protein or water content encountered is not more than three to one, the ratio between highest and lowest fat values is more than 300 to one (Murray and Burt, 2001).

The nutritional benefits of fish, as compared to other animal proteins, mainly stem from its exceptionally advantageous fatty acid profile. In recent years increasing attention has been focused on significance of long chain n-3 polyunsaturated fatty acids (PUFAs) in human nutrition, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These fatty acids are normally found in fish. It is important for human health to ensure adequate consumption of n-3 PUFA as a means of preventing coronary heart diseases (WHO, 2008). Other significant sources of n-3 PUFA other than fish are selected vegetable oils, e.g. olive, canola, soybean (NCFFN, 2005). However, these oils are less commonly used in Malaysia. Palm oil represents the main cooking oil for most Malaysians, as this country is a primary producer of palm oil. Current consumption is 6.6kg per capita/year or 17.8g/capita/day (FAO, 2011). Its saturated fat is high at 50%. Coconut oil is another major source of saturated fat (at 92%) in the Malaysian diet as coconut milk is commonly used in preparing meals. Hence, fish remains as the prime source of n-3 PUFA in Malaysian diet. In fact, consumers in current study had poor knowledge of fish but all knew fish is the source of n-3 PUFA, or more commonly known locally as omega-3.

PUFA composition vary significantly among and within different fish species of both freshwater and marine origins, which are affected by many factors such as the temperature, salinity, season, size, age, habitat, life stage, and the type and abundance of food (Hossain, 2011). For wild fish, food availability and abundance in nature varies from year to year, season to season, and from location to location, and this affects the total fat level and its composition in fish tissues. The values found in nutrient databases are average values, not absolute amounts. One could sample a few wild fish and most likely find values for total fat level and percentage of n-3 PUFA in muscle tissue that differ from official values (Hardy, 2003). When habitat condition is conducive, wild marine fish, especially carnivores, have a natural diet rich in highly unsaturated n-3 PUFA. These fatty acids which are cumulative in the marine food chain depend on the primary producers such as marine phytoplankton (Ruiz-Lopez et al., 2012). These primary producers can effectively synthesise long chain PUFA from the short chain n-3, alpha-linolenic acid (ALA), and the short chain n-6, linoleic acid

(LA) via a series of desaturation and elongation reactions and are able to directly synthesise docosahexaenoic acid (DHA) from docosapentaenoic acid (DPA) (Strobel et al., 2012).

While the marine food chain is rich in the long chain n-3 eicosapentaenoic acid (EPA) and DHA, the freshwater food system contains higher levels of LA and ALA (Tocher, 2010) resulting in apparent differences between the fatty acid composition of freshwater and marine fish. It has been reported in a review article that the level of n-6 fatty acids as well as those of short chain n-3 PUFAs are rich in freshwater than in marine fish, the latter having higher concentration of long chain n-3 PUFAs (Hossain, 2011). Marine fish typically require n-3 highly unsaturated fatty acid (HUFA) for optimal growth and health (Craig and Helfrich, 2009). The two major EFA of this group are EPA and DHA. Freshwater fish do not require the long chain HUFA, but often require LA that cannot be produced by freshwater fish and must be supplied in the diet (Craig and Helfrich, 2009). Some freshwater fish can take this fatty acid, and through enzyme systems, manufacture the longer chain n-3 HUFA, EPA and DHA, which are necessary for other metabolic functions and as cellular membrane components (Craig and Helfrich, 2009). In other words, freshwater fish convert food of poor nutritional value into food of rich nutritional value. Marine fish typically do not possess these elongation and desaturation enzyme systems, and therefore require long chain n-3 HUFA in their diets (Craig and Helfrich, 2009).

On the other hand, farmed fish are provided with nutrient-dense formulated feed all year round, which enables them to deposit large reserves of lipids (Verbeke et al., 2007). The lipid composition of farmed fish is not only species specific but also highly dependent on feed content. The overall n-3 long chain PUFA levels in the flesh are ultimately determined by the levels in the feed (Sprague et al., 2016).The differences in total fat and fatty acid composition between wild and farmed fish can occur due to different feeds (artificial versus natural feed), seasonal variation, environmental temperature and geographical location (Hunter et al., 2001). Aquaculture production systems may be described either as extensive systems employing low animal density in relation to water volume or intensive systems in which higher animal density are used (Creti et al., 2010). In the intensive system, fish are bred in tanks and fed with formulated feed (Creti et al., 2010). In the extensive system, fish grow in lagoons or brackish waters, naturally fed (Creti et al., 2010). When the natural diet is supplemented with special feed, the system is defined semi-intensive (Creti et al., 2010). Karapanagiotidis et al. (2006) has proven in their study that PUFA content of farmed and wild tilapia in a major tilapia producer country, Thailand, would vary substantially according to aquaculture production systems. Wild fish reared under the most extensive conditions had a more favourable fatty acid profile for human consumption as they contained higher proportions of n-3 PUFAs (18:3n-3, 20:5n-3, and 22:6n-3) and higher n-3/n-6 PUFA ratios (Karapanagiotidis et al., 2006).

One popular perception among consumers is that farmed fish are inferior in terms of quality and nutritional content than wild fish (Sprague et al., 2016). Many efforts have been attempted in the west to investigate whether farmed fish are as good as the wild ones in being the source of omega 3 fatty acids (Nettleton and Exler, 1992; Haard, 1992; Serot et al., 1998; Alasalvar et al., 2002; Olsson et al., 2003; Cahu et al., 2004; EFSA 2005; Hamilton et al., 2005; Gonzalez et al.; 2006; Álvarez et al., 2009; Bhouri et al.; 2010; Hossain et al., 2011; Henriques et al., 2014; Lövkvist, 2014; USDA, 2015; Sprague et al., 2016). Because these studies were conducted in the west, they tended to focus on the most popular farmed species in the region, e.g. salmon, seabass, seabream and trout. These studies reported that farmed fish generally has higher total lipid content but when it is expressed relatively to their total fatty acid content, the levels of EPA and DHA are generally lower in the farmed species than that of their wild equivalents. However, with a higher total lipid content, the PUFA content per portion of farmed fish is ultimately equal to, if not higher, than wild fish (ESFA, 2005). Because fatty acid profiles are often presented as a percentage of the total lipid, this often leads to a misinterpretation regarding the perceived higher n-3 long chain PUFA nutritional content of wild fish compared to their farmed equivalents (Sprague et al., 2016). Moreover, the cholesterol and protein levels in farmed fish are similar to those of wild fish (Cahu et al., 2004). As such, it can be concluded that the nutritional content of farmed fish in these western countries is at least as beneficial as that of their wild equivalents, particularly in terms of coronary heart diseases prevention.

In the Malaysian context, it is not practical to conduct comparative researches on omega 3 content of the wild fish and their farmed equivalents since all of the commonly consumed marine fish are exclusively wild while commonly farmed species are usually from the freshwater. It would be unfair to have a general comparison because it is widely known that freshwater fish tend to have lower amount of omega 3 fatty acids regardless of whether they are farmed or not. In an attempt to compare the omega 3 contents between the commonly consumed and commercially important fish in Malaysia, a review was conducted to pool in data from Malaysian papers. A total of 8 studies were found upon searching on Sciencedirect and Google Scholar with the following keywords: “fatty acid composition”, “fish” and “Malaysia”; only 6 were chosen while another 2 studies were rejected due to lack of working data. Relevant data were extracted from the selected papers, converted and expressed in mg/100g edible portion, and then averaged accordingly. For comparison purpose, data from the Singapore Food Composition Database (Ministry of Health Singapore, 2011) were also included where available. Some other protein sources, i.e. salmon (more popular among urbanites) and some popular terrestrial animals, were also included for comparison. The Malaysian Food Composition Database was not referred to because it did not measure fatty acid composition.

Table 43: Content of total fat, Omega 3 fatty acid and EPA+DPA in popularly consumed fishes in Malaysia. (References listed in the table below.)

Common Wild Captured Marine Fish	**Total Fat (g/100g Edible Portion)**	**PUFA ω-3 (mg/100g Edible Portion)**	**EPA + DHA (mg/100g Edible Portion)**
Spanish Mackerel *(Scomberomorus commerson)*	**x̄=1.47**	**x̄=470.2**	**x̄=341.0**
Abd Aziz et al. (2013)	1.05	314.2	97.5
Osman et al. (2001)	1.46	626.2	425.6
Ministry of Health Singapore(2011)	1.90	-	500.0
Stingray *(Dasyatidae spp.)*	**x̄=1.03**	**x̄=567.3**	**x̄=161.1**
Abd Aziz et al. (2013)	0.93	375.5	11.7
Osman et al. (2001)	1.95	759.1	441.7
Ministry of Health Singapore(2011)	0.22	-	30.0
Fourfinger Threadfin *(Eleutheronema tetradactylum)*	**x̄=1.78**	**x̄=562.6**	**x̄=251.8**
Abd Aziz et al. (2013)	2.10	460.6	149.3
Osman et al. (2001)	2.24	664.6	354.3
Ministry of Health Singapore (2011)	1.00	-	-
Silver Pomfret *(Pampus argenteus)*	**x̄=3.20**	**x̄=747.5**	**x̄=414.7**
Abd Aziz et al. (2013)	2.09	571.6	264.3
Osman et al. (2001)	2.91	923.3	573.9
Ministry of Health Singapore (2011)	4.60	-	406.0
Black Pomfret *(Parastromateus niger)*	**x̄=3.24**	**x̄=782.4**	**x̄=509.4**
Abd Aziz et al. (2013)	2.33	714.3	350.6
Osman et al. (2001)	2.79	850.4	405.6
Ministry of Health Singapore (2011)	4.60	-	772.0
Hardtail Scad *(Megalaspis cordyla)*	**x̄=2.72**	**x̄=931.0**	**x̄=761.1**
Abd Aziz et al. (2013)	1.53	387.0	214.9
Osman et al. (2001)	3.08	1475.0	1058.3
Ministry of Health Singapore (2011)	3.55	-	1010.0
Indian Mackerel *(Rastrelliger kanagurta)*	**x̄=3.2**	**x̄=1048.1**	**x̄=505.5**
Muhamad et al. (2012)	4.54	1438.3	702.4
Abd Aziz et al. (2013)	1.80	190.5	76.9
Osman et al. (2001)	4.54	1515.5	872.6
Ministry of Health Singapore (2011)	1.73	-	370.0
Yellow Striped Scad *(Selaroides leptolepis)*	**x̄=3.26**	**x̄=1898.6**	**x̄=1169.2**
Abd Aziz et al. (2013)	2.12	1417.0	879.15
Osman et al. (2001)	5.77	2380.1	1798.3
Ministry of Health Singapore (2011)	1.90	-	830.0

Threadfin Bream (*Nemipterus bathybius)*	**x̄=3.07**	**x̄=796.5**	**x̄=551.7**
Abd Aziz et al. (2013)	2.70	796.5	551.7
Ministry of Health Singapore (2011)	3.43	-	-
Sardine *(Sardinella spp)*	**x̄=3.79**	**x̄=839.5**	**x̄=549.7**
Abd Aziz et al. (2013)	3.00	734.6	436.9
Osman et al. (2001)	3.06	944.3	662.5
Ministry of Health Singapore (2011)	5.30	-	-
Anchovies *(Stolephorus spp.)*	**x̄=2.80**	**x̄=727.0**	**x̄=129.5**
Muhamad et al. (2012)	2.50	727.0	129.5
Ministry of Health Singapore (2011)	3.10	-	-
Common Farmed Fish	**Total Fat (g/100g Edible Portion)**	**PUFA ω-3 (mg/100g Edible Portion)**	**EPA + DHA (mg/100g Edible Portion)**
Catfish *(Clarias batrachus)*	**x̄=12.01**	**x̄=195.4**	**x̄=36.7**
Muhamad et al. (2012)	4.25	236.7	31.5
Endinkeau and Tan (1993)	12.96	111.5	71.3
Abd Rahnan et al. (1995)	20.0	238.0	44.0
Ministry of Health Singapore (2011)	10.83	-	-
Barramundi *(Lates calcarifer)*	**x̄=2.81**	**x̄=509.4**	**x̄=220.0**
Abd Aziz et al. (2013)	2.68	933.0	234.9
Endinkeau and Tan (1993)	1.97	153.1	151.5
Abd Rahnan et al. (1995)	6.50	442.0	273.7
Ministry of Health Singapore (2011)	0.10	-	-
Tilapia *(Oreochromis spp.)*	**x̄=5.19**	**x̄=202.7**	**x̄=60.0**
Endinkeau and Tan (1993)	11.01	210.3	96.9
Abd Rahnan et al. (1995)	2.75	195.0	23.1
Ministry of Health Singapore (2011)	1.80	-	-
Golden Snapper *(Lutjanus inermis)*	**x̄=1.60**	**x̄=506.3**	**x̄=146.0**
Abd Aziz et al. (2013)	1.29	506.3	25.9
Ministry of Health Singapore (2011)	1.90	-	266.0
Red Snapper *(Lutjanus campechanus)*	**x̄=1.64**	**x̄=724.7**	**x̄=282.0**
Abd Aziz et al. (2013)	1.37	724.7	234.0
Ministry of Health Singapore (2011)	1.90	-	330.0
Big Head Carp *(Hypophthalmichthys nobilis)*	**x̄=2.87**	**x̄=54.4**	**x̄=4.6**
Abd Rahnan et al. (1995)	1.75	54.4	4.6
Ministry of Health Singapore (2011)	3.98	-	-
Salmon *(Salmo salar)*	**x̄=13.66**	**x̄=2692.0**	**x̄=1671.5**
Ministry of Health Singapore (2011)	13.90	-	1377.0
USDA*	13.42	2692.0	1966.0
Common Terrestrial Animals	**Total Fat (g/100g Edible Portion)**	**PUFA ω-3 (mg/100g Edible Portion)**	**EPA + DHA (mg/100g Edible Portion)**

Chicken (Ground) Ministry of Health Singapore (2011)	**8.1**	-	**31.0**
Beef (Lean) Ministry of Health Singapore (2011)	**3.7**	-	**25.0**
Pork (Lean) Ministry of Health Singapore (2011)	**1.6**	-	**6.0**

*Farmed Atlantic

The compilation of the fatty acid composition of selected fish in Malaysia (Table 43) shows similar trends in agreement with the findings in previous literature. Large variances are evident in the n-3 fatty acid levels within each species, regardless of whether farmed or wild, marine or freshwater. For instance, the total lipid content of catfish ranges from 4.25 to 20.0 g/100g edible portion whereas the EPA+DHA contents of Indian mackerel and yellow striped scad range from 76.9 to 872.6 and 830.0 to 1798.3 mg/100g edible portion respectively (Table 43). In addition, freshwater fish in general have lower omega 3 content compared to the marine fish. While it is baseless for consumers in current study to claim that wild fish is generally more nutritious in terms of beneficial fats than farmed equivalents, it is undeniable that common wild captured marine fish, especially the popular Indian mackerel and scads, are significant sources of omega 3 in their diet. In fact, the Indian mackerel and yellow-striped scad appear to be good candidates to replace the imported cold-water fatty fish e.g. salmon. Furthermore, the fact that farmed freshwater fish in Malaysia has lower omega-3 content and higher saturated fatty acid content than wild fish does not make it more advantageous nutritionally than other farmed terrestrial livestock. Similarly, Usydus et al. (2011) found that the farmed fish imported from China and Vietnam (walleye pollock, sole, sutchi catfish and tilapia) are characterised by low contents of EPA and DHA, and therefore concluded as not significant for coronary heart disease prevention. In the Malaysian context, the perception of wild fish as more nutritious appears to be understandable albeit due to unfair inter-specific comparison.

6.4.5 "The level of contaminants is higher in farmed than wild fish"

Environmental pollutants such as dioxins and polychlorinated biphenyls (PCB), heavy metals, and organochlorine pesticides are a global threat to human health because the aquatic biota can bioaccumulate many of these contaminants potentially making the consumption of these aquatic food a source of chronic exposure (Nøstbakken et al., 2015). Prolonged exposure to these substances may cause deleterious health effects such as elevated risk of cancer, neurotoxicity and damages to bodily organs and systems in human (Järup, 2003; Alavanja et al., 2004). Fish bioaccumulate these pollutants in their body via two routes: aqueous uptake of water-borne chemicals and dietary uptake by ingestion of contaminated food (Streit, 1998). Both wild and farmed fish can be directly exposed to contaminants leached out from industrial, agricultural and municipal waste but the concentration of contaminants in fish depends on the origin of the fish and its distance from the source of pollutants, the type of tissue sampled, the season of harvest and, specifically for farmed fish, the composition of the fish feed (EFSA, 2005; Verbeke et al., 2007).

The distribution and potential bioaccumulation of dietary and waterborne cadmium and lead in tissues of sea bream (Sparus aurata), a major aquaculture species in Italy, was studied by Creti et al. (2010) in relation to three different systems: in the intensive system, fish are bred in tanks and fed with special feed fitting each single species; in the extensive system, fish grow in lagoons or brackish waters, naturally fed; when the natural diet is supplemented with special feed, the system is defined as semi-intensive. Results demonstrated that metal concentrations in various tissues significantly varied among fish culture systems, with the lowest levels found in extensive system while the highest levels were seen among intensive systems. This was because most marine fish culture sites were generally located in shallow inlets more or less completely enclosed by coastlines so that fish cages are protected from waves. This semi-enclosed nature reduced water circulation and exasperated pollution problems in many fish culture sites (Creti et al., 2010). Apart from high stocking density, the use of contaminated fish as feed can generate high nutrient loading and biomagnification processes in intensive systems. The intensively farmed fish were found to have higher metal concentrations than the semi-intensive ones because of their higher exposure to fishmeal produced from contaminated trash fish (Creti et al., 2010). This intensive production raises concerns over the quality of farmed fish in comparison to wild fish.

Having analysed over 2 metric tons of farmed (from eight major producing regions in the Northern and Southern hemispheres) and wild salmon from around the world for organochlorine contaminants, including PCB, dioxin, toxaphene, and dieldrin, Hites et al. (2004) showed that concentrations of these contaminants were significantly higher in farmed salmon than in wild. Hites et al. (2014) hypothesised that the elevated levels of contaminants in farmed salmon were most likely due to the contamination of the feed (that is a concentrated source of fish oils and fish meal) because uptake of organic contaminants from water to fish is a minor accumulation pathway. They subsequently analysed 13 samples of commercial salmon feed and confirmed that the levels of contaminants in these feeds were generally similar to or greater than those found in the farmed salmon. This may reflect higher contaminant concentrations in forage fish from the industrialised waters where forage fish were harvested for fishmeal and fish oil (FAO, 2001).

However, the findings are different in Malaysian context. Azlan et al. examined the levels of polychlorinated dibenzo-p-dioxins/ polychlorinated dibenzofurans (PCDDs/PCDFs) in popular marine fish caught off the Straits of Malacca in two separate studies in 2011 and in 2015. The marine fish and shellfish samples consisted of the following exclusively/predominantly wild species: Indian mackerel, Spanish mackerel, silver pomfret, hardtail scad, fourfinger threadfin, dorab wolf-herring, large-scale tongue sole, long-tailed butterfly ray, Japanese threadfin bream, sixbar grouper, Malabar red snapper, grey eel-catfish, cockles, prawn and cuttlefish. In their 2015 study, the total PCDD/PCDF in the fish and shellfish samples ranged between 4.6 and 21.8 pg WHO-TEQ*/g fat. As the safe level of PCDD/PCDF in food is set at 1 pg WHO-TEQ*/g fat (Codex Alimentarius Commission, 2006), the investigators concluded that samples from the Straits of Malacca were not safe for consumption. Conversely, the total PCDDs/PCDFs (pg WHO-TEQ*/g FW) for fish fillet samples of Indian mackerel (0.10), silver pomfret (0.13), grey eel-catfish (1.23), hardtail scad (0.12) and Spanish mackerel (0.18) as reported by Azrina et al. in 2011 were lower than the levels determined in the 2015 study. Another 2014 study in Malaysia reported that the mean levels of PCDD/PCDF in eight types of fish (including the predominantly farmed tilapia, grouper and barramundi) ranged from 0.16 to 0.17 pg WHO-TEQ*/g FW (Leong et al., 2014) and were also much lower than the concentrations of PCDD/PCDF as reported by Azlan et al. (2015). It appears that contamination in wild fish is becoming more prevalent but there is not enough evidence to conclude that it is more contaminated than the farmed ones.

Wide variations have also been observed in the reported values of heavy mineral concentrations in the equivalent species of wild and farmed fish of studies conducted in other countries (Fallah et al., 2011; Foran et al., 2004; Padula et al., 2008; Yildiz, 2008; Yipel et al., 2016). Similarly in Malaysia, studies show that the concentrations of the toxic elements (e.g. arsenic, cadmium, lead and mercury) in tissues of farmed fish do not show a consistent pattern of elevation and do not occur in either farmed or wild fish at levels that pose a threat to human health (Agusa et al., 2007; Alina et al., 2012; Ahmad et al., 2015). The differences in levels of trace element accumulation may be attributed to feeding, habitat, behaviour, ecological needs, and metabolic activity (Kalantzi et al., 2013). Variability in sampling procedures and analytical techniques employed might also influence the results (Alasalvar et al., 2002). The effect of inconsistent adoption of international residue and contaminant nomenclature coupled with differing reporting conventions for risk management decision making and differing sample collection and processing methods creates ambiguity and may lead to different consumer interpretations (Padula et al., 2008).

Although current literature has yet to prove so, the prevailing view within the aquaculture industry is that health and safety qualities will eventually be an advantage to the fish farmers owing to the fact that, unlike fishermen, fish farmers can manipulate the production processes to control the levels of toxic contaminants and pathogens in their fish throughout (Verbeke et al., 2007). Fish from wild sources can bioaccumulate more trace elements than farmed fish due to unmanageable, polluted surface waters or sediments and the concentration of these metals in the food chain that are beyond fishermen's control. While fishermen could not control the diet of wild fish, it is possible for fish farmer to directly control tissue contaminant levels by using specially formulated diets (EFSA, 2005). The advantage over wild capture fishery can also be attributed to the fact that high-risk locations can be conveniently avoided by proper site evaluation and implementation of good aquaculture practices (Jensen and Greenlees, 1997).

However, not all aquaculture entities are operated to such ideal standard. Some data mined from the literature suggested the presence of erratic aquaculture practices in Malaysia. For instance, there is emerging evidence of unregulated inclusion of prohibited antibiotics in fish feed. While several importing countries (the United States, Canada and European Union) have banned chloramphenicol from use in animals intended for food production (Serrano, 2005), Sapkota et al. (2008) reported that of the top 13 aquaculture producing countries (excluding Egypt and North Korea), 69% used chloramphenicol. Sporadic studies conducted in Malaysia showed the frequent and persistent occurrence of multiple resistances to antibiotics, including the banned chloramphenicol. In fact, a number of shipments of farmed shrimp to the United States from Malaysia were rejected because the shrimps were tested positive for chloramphenicol residue (FDA, 2016). The history of cultivated shrimp production has been punctuated by disease epidemics that have caused crashes in the production (Cock, 2015). The devastating impact of persistent diseases in prawn farming was repeatedly highlighted by both wholesalers and aquaculturists in Chapter 4. The issuance of 'import alert' by US FDA on prawns from Malaysia due to the detection of banned antibiotics (FDA, 2016) suggests that large quantities of antimicrobials are used in prawn aquaculture in Malaysia, often without professional consultation or supervision, to combat the disease epidemics.

The confession of one aquaculturist that she did not want to consume her own product because fear of the side effect of the "numerous chemicals used in fish farming" carries a lot of weight. The issues of uncontrolled use of antimicrobial agents and the detection of its residue in farmed products have important public health implications. When antibiotics are unintentionally ingested as residues in food, the amount ingested cannot be quantified or monitored and may cause direct health concerns, such as aplastic anaemia, which is reported to be associated with chloramphenicol (WHO, 2006). Over time, it may lead to the development of antibiotic resistance in bacteria that are pathogenic to humans (FAO, 2002). The problem arises when bacteria acquire resistance to one or more of the antibiotics to which they were formerly susceptible, and when that resistance eventually makes the antibiotics ineffective in treating specific microbial diseases in humans (FAO, 2002). Apart from direct ingestion of antimicrobial residues in food, antimicrobial use in aquaculture production may also contribute to microbial responses and antimicrobial resistance in bacteria that may be transmitted to humans: those who are involved in the production chain are at risk of exposure to resistant bacteria and are more likely to be infected with methicillin-resistant Staphylococcus aureus (MRSA-398) than other individuals in the community (Garcia-Alvarez et al., 2012).

Although typical aquaculture production methods are stringent and designed to provide the safest means for producing quality-controlled fish, there is no convincing scientific evidence that confirms farmed fish are safer than wild fish or vice versa. This ambiguous picture is consistent with consumer beliefs—i.e. there were almost as many respondents who scored neutral as there were who thought farmed was unsafe. The potential advantages of farmed fish over wild ones in terms of monitoring, traceability and controlling for health and safety issues have apparently not yet been fully exploited by fish farmers to their benefit. Considering the presence of unscrupulous farming practices and consumers' poor knowledge of aquaculture systems and fisheries in general, it is understandable that consumers held the perception that wild fish are safer than farmed fish.

6.5 CONCLUSION

The controversy about eating farmed versus wild fish is complex and there is no simple answer to say which is better. When comparing scientific evidence with consumer perceptions, the gap between facts and their perception seems to be the largest for freshness and sensory characteristics. Although there is a general impact of the life history of the fish in its final attribute, the differences in texture might be offset after undergoing storage (Alasalvar et al., 2002). First processing steps of fish have common practices for wild and for farmed fish but fish farming does have certain advantages over capture fisheries in that the processor can influence post-mortem biochemistry and freshness and quality parameters. On top of that, aquaculturists have an advantage over fishermen since they can manipulate different stages of the farming and processing steps to produce a "bespoke" fish tailored according to consumers' preferred attributes. Unknown to the consumers is the fact that most of the factors affecting the typical aroma of fish, e.g. the n-3 PUFA content of muscle, dietary pattern and water quality, can be manipulated by farmers and fish feed producer whereas the diet of wild fish falls beyond human control.

On the other hand, healthiness and nutritional composition are the most ambiguous in terms of scientific evidence because these factors depend largely on the farming conditions. In Europe, many works on differentiation of proximate composition, fatty acid composition between wild and farmed fish has been done for authentication analyses, for example to reliably differentiate between wild and farmed Atlantic salmon, cod, European sea bass and sea bream. In Malaysia, an "apple to apple comparison" between the wild and farmed species could not be done because commercial fish are either exclusively wild or exclusively farmed. The examination of the fatty acid composition of selected fish in Malaysia shows that wild captured marine fish, especially the popular Indian mackerel and scads, are as good as the imported cold-water salmon in providing beneficial omega 3 supplies in the Malaysian diet and are even better than salmon in terms of carbon footprint. Conversely, the omega-3 content of the commonly consumed farmed fish, i.e. tilapia and catfish, in Malaysia is low and does not provide significant nutritional advantage in terms of this omega 3 content than other farmed terrestrial animal protein such as chicken. The role of these commonly consumed wild captured marine fish in Malaysian diet is deemed irreplaceable by farmed ones – at least not yet. This means that simply producing more food via aquaculture is not quite the correct answer to the declining wild fish stock. The focus of aquaculture production systems must move beyond maximising yields to also consider nutritional quality. The ambiguity is also seen in the comparison of safety risks. It cannot be scientifically confirmed as yet that farmed fish are safer and/or more nutritious than wild fish, or vice versa.

Although its actual magnitude is unknown, data mined from the literature suggested the persistent presence of erratic aquaculture practices in Malaysia that produce substandard product and give bad name to the industry. It is concluded that the aquaculture industry has still a great deal of work to do, particularly in water quality management, disease control, policing good practice and improving traceability. The relevant authorities should invest in training and raising awareness among aquaculturists. Legislation on fish stocking rate, feed formulation and the use of antibiotics should be made more stringent. It is also largely unknown by consumers the fact that aquaculture has potential advantages over wild fisheries in terms of the ability to control and manipulation of many safety, organoleptic and quality-defining attributes of farmed fish. The future success of Malaysian aquaculture is built upon its ability to improve its current practices, so that its potential advantages over capture fisheries can be exploited, and finally to effectively promote the resulting benefits to consumers.

CHAPTER 7: DISCUSSION AND CONCLUSION

The scope of the thesis was broad to give as holistic a picture as possible about the status of fish in Malaysian diets. The main aims of the project were to identify signs of unsustainability of current fish consumption habits while at the same time to consider whether aquacultured product can be a suitable substitution for wild fish. The review of the Malaysian food balance sheets in Chapter 2 showed a significant transition in diet over the last three decades, specifically with respect to an increase in animal protein by approximately 60% over this time, with fish as the major source of protein. To further explore the contribution of fish to the diet of Malaysians and any ethnic and geographical differences in consumption, a food frequency questionnaire (FFQ) was developed to assess habitual dietary intakes within selected coastal, rural and urban populations across different cultural groups in the Klang Valley. This study generated new baseline information that was not previously known. The FFQ provided a clearer picture of the quantity and types of fish consumed by Malaysians and has enabled the characterisation of Malaysian fish consumers based on the types of fish species consumed. Results from this study, combined with detailed studies of the perceptions of consumers, aquaculturists and wholesalers to wild versus farmed fish, provided a greater understanding of consumers' dietary habit, their knowledge and understanding of where the fish come from, why they buy and consume fish and their perceptions of many attributes of wild versus farmed fish. The key findings are discussed with respect to the sustainability of the current situation, potential for expanding the aquaculture sector and recommendations for future research and issues for policy makers involved in the expansion of the industry.

7.1 MAIN FINDINGS

In Chapter 2, five interrelated research questions were identified, which the thesis has attempted to answer. The research questions guiding the thesis are listed again in turn, with specific responses to demonstrate how the thesis has answered each of them:

R1. What is the fish-eating habit in Malaysia?
R2. Is their fish consumption habit sustainable?

The thesis addressed these two questions with a multitude of methods: analysis of Food Balance Sheets, MANS and NHMS (Chapter 3) for background information; development of an FFQ to assess dietary intake (Chapter 4); and finally the cross-checking of results from FFQ against official landing statistics by species, import/export statistics by species, fishing /farming practices by species, and International Union for Conservation of Nature (IUCN) Red list database for sustainability assessment purpose.

The analysis of Food Balance Sheets, MANS and NHMS in Chapter 3 demonstrated warning signs that the current trend in the diet of Malaysian population might prove unsustainable. The key warning signs are persistent overabundance (overproduction) of food coupled with the alarmingly increasing prevalence of non-communicable diseases (NCD) and their risk factors in Malaysia. It was found that the energy supply for the Malaysian population consistently remained in excess of average calorie needs, by a minimum of 30%. There were significant signs of shifting food trends, particularly in the supply of wheat (+56.5%), rice (-23.7%), sugar and sweeteners (+23.9%), meat (+49.3%), fish and seafood (+38.7%), and eggs (+55.7%). Demographics and NHMS data series suggested the coexistence of undernutrition, overnutrition and "hidden hunger". Prevalence of NCD and its risk factors has increased rapidly, some as high as 170%, in the recent 20 years (Chapter 3). Further investigation using the FFQ as an individual dietary assessment tool, has confirmed the overconsumption of environmentally costly animal protein. The plant/animal protein ratio is at a low of 3:4 for an average adult and the average consumption of meat and poultry is 100% more than the recommended serving size (Chapter 4). On average, fish is the most consumed animal protein in terms of volume. It comprises of about one-third of total animal protein consumed, with the highest consumption observed in the coastal (51.9 kg/year) and rural (51.8 kg/year) areas and lowest in the urban area (36.9 kg/year) (Chapter 4).

The Malaysian dietary guideline (Appendix H) recommends the consumption of at least one serving of fish daily; those from the coastal and rural areas are consuming enough to meet the recommended dietary guideline while the urbanites are consuming 30% less than the recommended amount (Chapter 4). Nonetheless the recommended serving is relatively high compared to many other countries, including close neighbour Singapore that shares similar traditions and culture, which usually advised for consumption of at least two servings of fish a week (assuming 20g of protein per serving). The Malaysian dietary guideline for fish (i.e. at least one serving of fish that is equivalent to 14g of protein per day; Appendix H) was stipulated without considering two important aspects, i.e. sustainability and toxicity of overconsumption. The recommendation of one serving per day might just be based on the fact that fish is widely available and is a traditional staple in the Malaysian diet. It is generally acknowledged that such high levels of fish consumption are not sustainable in the long term as the productivity of ecosystems is expected to be the limiting factor. Although marine fish landings showed a fairly stable trend, fishing effort has reportedly increased in the last 10 years. The proportion of edible food fish in the catch has also declined with trash fish accounting for on average 30% of DoFM reported landings from 2000-2010 in Peninsular Malaysia. Catch reconstructions reveal that local marine fisheries catches are higher than reported but are declining due to poorly documented subsistence and illegal fisheries. The inshore fisheries resources of Malaysia remain overexploited.

One of the most important features of the FFQ study in Chapter 4 is to furnish a list of commonly consumed fish species for the evaluation of the sustainability of fish consumption in terms of adherence to local fish and seasonality and eco-friendliness of fish production. Small pelagic fish such as mackerels are amongst the most important fish landed and consumed in Malaysia. Undeniably, small pelagic species are commonly known as the more sustainable choice due to their lower trophic levels. However, if substantial amounts of lower trophic species are uncontrollably removed from the ecosystem, the livelihood of a wide range of predators could be affected (Smith et al., 2011). Some of the commonly consumed species (e.g. stingray, small tuna, scad) have been listed on the IUCN Red List database due to declining fish stock as a result of heavy exploitation. In addition, the need to import most of the nation's favourite fish from countries such as Thailand and Indonesia to fulfil local requirement compels for consideration into the sustainability and carbon footprint of the fisheries sector. From an economic viewpoint, the increasing reliance on imports to fulfil local demand has caused a trade deficit for the industry. Moreover the lack of governance and monitoring of fisheries not only in Malaysia, but in most developing countries and neighbouring countries that Malaysia import fish from, exacerbate the problem of overfishing, destructive fishing (such as trawling) and environmental degradation that leads to the deterioration of ocean fish stock. There is a clear need to shift the diet of the Malaysian population according to local seasonality and eco-friendliness.

The review of FBS, dietary assessments, diet related morbidity and mortality statistics, and fisheries statistics all indicate the unsustainability of current consumption and production patterns. Evidence strongly points towards the need to eat less fish – not more sustainable fish, as with other sources of animal protein. Alternatives such as soybean/soybean products ("taufu", "fucok" and "taugeh") and legumes (beans and peas) were once a staple in the population's diet but are now under-consumed (Ng, 2006) at an average of only 1 cup per week (Chapter 4). Apart from being a good protein source, one serving of soybean products provides from 77 to 300 mg alpha-linolenic acid (ALA) (Ng, 2006). Consumption of these products should be promoted again as an important feature of a varied well-balanced diet. It may help consumers to achieve their daily requirements for these important fatty acids while reducing the reliance on animal (fish-based) protein sources.

R3. What are the barriers and opportunities for aquaculture market expansion in Malaysia?

The demand for fish is expected to increase with increasing population and the increasing awareness of fish as a healthy food. To achieve the objectives of sustainability of resources and the provision of sufficient nutritious food is a great challenge. Many efforts are beginning to be put into expansion of the aquaculture industry in anticipation that farmed products can be an alternative option to wild captured fish, as well as being exported to pay for the fish import bill. Market surveys were conducted on fish wholesalers' and aquaculturists' to elicit their views on the opportunities and barriers to increasing market expansion and consumption of farmed fish (Chapter 5). The result of the interviews highlighted several pertinent issues. The underlying paradox of aquaculture industry was confirmed: aquaculture is a possible solution, but also a contributing factor, to the collapse of fisheries stocks worldwide. The decline of capture fishery resources was recognised by the industry players as a good opportunity for the growth and expansion of the industry. However, at the same time, the aquaculturists have found that the declining amount of trash fish available for fish feed is one of the challenges to the growth of the industry. The sustainability of Malaysian fish consumption cannot yet be improved by increasing the proportion of farmed fish in the diet. There are still many other adaptive and technical challenges that this new industry has to overcome.

The cited challenges of the external environment include a variety of factors outside the organisations that the businesses typically do not have much control over, hence, would not be further discussed here. Examples of the external environment factors are abnormal climatic pattern, water and land quality degradation, market volatility, financial crisis, cheaper substitutes and trade disputes, crop loss (production uncertainties), difficulty acquiring loan and pathogens and diseases. The internal business environment includes factors within the organisation that impact the approach and success of operations and could be worked upon for improvement. Internal factors such as self-induced risks due to irresponsibility, bad press and consumer prejudice are factors that were repeatedly highlighted during the interviews. It would appear that farmed fish are not a popular choice since they only comprised on average 25% of the total fish consumed (Chapter 4).

Herbivorous aquaculture species is the most commonly available type of farmed fish for local consumption. They have a low requirement for fishmeal and fish-oil in their diets, making them net producers of protein and are therefore more sustainable options (Huntington and Hasan, 2009). Most of the fish that fall into this group are of freshwater origin. Unfortunately, these freshwater fish are not a popular option among Malaysian consumers (Chapter 4). Malaysians have a high affinity for wild captured marine fish (Chapter 4) while certain farmed fish that have lower environmental impact are less preferred and remain underutilised. The interviews suggested that Malaysians are wary of consuming these fish because their flesh often carries a “muddy” flavour. It was also suggested that consumers are likely to have negative perceptions towards farmed products. The interviews suggested that these negative perceptions could arise from poor consumption experience in the past (e.g. having bought fish with strong muddy flavour), bad press coverage or just irrational prejudice.

The “muddy” flavour may be attributable to the microbiological quality of water as the aroma of the fish is heavily influenced by the presence of certain organisms and algae in the aquatic environment (Orban et al., 1997), and this is especially true for freshwater fish. The most common off-flavour compounds in freshwater fish, geosmin (GSM) and 2-methylisoborneol (2-MIB), are unique to fresh water and are produced and released from cyanobacteria species into the water (Smith et al., 2008). The levels of GSM and 2-MIB increase as water quality deteriorates in stagnant water as a result of eutrophication which promotes cyanobacterial blooms (Gutierrez et al., 2013; Pimolrat et al., 2015). This suggests the lack of proper water quality management by some irresponsible farm owners that could have been straightforwardly prevented. Similarly, the bad press coverage could have stemmed from the presence of unscrupulous farm owners. The devastating impact of persistent diseases in prawn farming was repeatedly highlighted by both wholesalers and aquaculturists in Chapter 5. The issuance of 'import alert' by US FDA on prawns from Malaysia due to the detection of banned antibiotics (FDA, 2016) suggests that large quantities of antimicrobials are used in prawn aquaculture in Malaysia, often without professional consultation or supervision, to combat the disease epidemics. The lack of governance and law enforcement could have contributed to the lacking of sense of social responsibility among farmers. The researcher was informed during a Q&A session with officers from DoFM that they were not able to conduct regular inspection and auditing of farms except when the farm applied for an export permit, due to lack of resources. As for consumer perception and acceptance, it is likely to be a result of pure prejudice and/or lack of integrity of farmed products which Chapter 6 has set out to explore further.

R4. What is the fish purchasing behaviour in Malaysia?

R5. What are the public perceptions of farmed fish?

The consumer survey study (Chapter 6) explained the relationship between socio-demographic variables and knowledge with fish purchasing behaviours, the frequency of farmed fish purchase and the perceptions towards farmed fish. Perception of fish as a healthy food was rated as the most important factor that encouraged the purchase of fish. Consumers regarded freshness, judged by visual and olfactory appeals, as the most influential factor in determining which type of fish to buy, whereas product origin and sustainability were the least important factors to consider at the point of purchase. The consumers had a generally poor knowledge about the origin and methods of harvest/production of fish. It is not surprising that consumers who self-proclaimed to be a non-consumer of farmed fish have ironically reported regular purchase of Vannamei prawn at least once a month. Generally, the urbanites and Chinese are less engaged and motivated in terms of fish purchase. They have median scoring tendency when confronted with questions using Likert scales. It was noticed that they consistently avoided extreme options, and hence, comparing Likert scale score across different geographical region and ethnicities would yield meaningless interpretation.

Negative prejudice towards farmed products in terms of quality-defining attributes was confirmed. The consumers' perception of farmed fish as inferior in terms of quality-defining attributes, i.e. freshness, taste, texture, health benefits and contaminant content, was confirmed to be prevalent, and could partially explain the low popularity of farmed fish consumption as compared to wild fish. Consumers' belief and prejudice were in contrast to other views reported in the literature with scientific evidence. The possible differences between farmed and wild fish in terms of organoleptic characteristics, nutritional value and safety were reviewed. When comparing scientific evidence with consumer perceptions, an "apple to apple comparison" between the wild and farmed species could not be easily done in Malaysia because commercial fish sold here are either exclusively wild or exclusively farmed. Nonetheless, after careful literature search, it was found that the negative perceptions among consumers are not entirely baseless. A few prejudices were proven worthy of concern and monitoring and were related to the lack of ethics and integrity in the aquaculture industry, fuelled by lack of policing and governance.

7.2 REVISITING RESEARCH PROBLEM: IS FARMED FISH CAPABLE OF REPLACING WILD-CAUGHT FISH IN THE MALAYSIAN DIET?

Undeniably, fish farming does have advantages over capture fisheries in that the aquaculturists possess the ability to manipulate certain post-mortem biochemistry and freshness and quality parameters at different stages of the farming and harvesting steps to produce a "bespoke" fish with consumers' preferred attributes. However, it was found that not all aquaculturists took advantage of these opportunities. Data collected from the literature and testimonies from wholesalers and aquaculturists during interviews suggested the erratic aquaculture practices in Malaysia could cause inferior qualities in farmed products. For instance, the widely unacceptable "muddy" aftertaste in some farmed fish is a result of poor water management. The perceived image of farmed fish as "unnatural and chemical laced" is related to the incidences of detection of prohibited drug residue in farmed products. Healthiness and nutritional composition are the most ambiguous because these factors are highly dependent on the farming practices. A review of current literature shows that wild captured marine fish, especially the popular Indian mackerel and scads, are the major omega 3 sources in the Malaysian diet. Furthermore, the lower content of long chain omega-3 in the common farmed fish in Malaysia does not seem to provide significant nutritional advantage over other farmed terrestrial livestock in terms of this key nutrient. This mainly arises as a result of fish farmers using fish feed rich in terrestrial feed. The nutritional role of these popular wild captured marine fish in Malaysian diet is deemed irreplaceable as yet.

The future success of the Malaysian aquaculture industry is likely to depend on its ability to overcome several key challenges. It has to sustainably exploit its potential advantages over capture fisheries and to remove consumers' prejudice by communicating the resulting benefits effectively to consumers. While it is confirmed that the consumers surveyed had low subjective knowledge on the sustainability of food choices, there does appear to be a window for modification of perception, especially through public education via different mediums, taking a lead from the successful efforts employed to promote the health benefits of fish (and fish oil) as a source of omega-3. Fish consumers are highly segmented and this high market segmentation presents a challenge for the popularisation of farmed products. It is important for aquaculturists, for the purpose of future establishment and expansion, to note that health benefits and freshness are the most important issues to be considered by an average Malaysian at the point of purchase of fish. Current and future policies must not only focus on maximising yields sustainably but also consider the nutritional quality of the products. Before public effort is made to modify consumers' negative perceptions towards farming of aquatic species, it is important that the high level of ethics and integrity of aquaculture industry is assured and maintained. The poor farming practices of a few can spoil it for the others and have a major negative impact on the willingness of consumers to trust any farmed products. Improved traceability and labelling and adherence to codes of conduct, for instance, can give consumers confidence in the product.

7.3 IMPLICATIONS AND PERSPECTIVES FOR STAKEHOLDERS

7.3.1 Improving the Monitoring and Surveillance of Fisheries Activities

Efforts to improve the sustainability of fish production require responsible use of marine resources. To reduce the stress on wild fish stock due to high demand and local fishing practices that were found to negatively impact the marine environment, the consumption of marine wild fish should preferably be reduced. To achieve this, the move to shift the demand on fish to aquaculture is inevitable. However, what is more urgent is the need for government to establish systematic surveillance, monitoring and reporting of the capture fishery industry as well as the strict policing of laws and regulation that deter destructive and illegal capture fishery. For aquaculture industry, the implementation of national strategies on biosecurity and veterinary health management, especially the monitoring of veterinary drugs use, is of utmost urgency.

The importance of managing fisheries through an ecosystem based approach while reducing waste and improving the efficiency of fisheries has been widely agreed upon. (Soto et al., 2008; Zhou et al., 2010; Thilsted et al., 2016). Ideally, the types of fisheries that generate greater edible returns, with lower greenhouse gases emissions and environmental impacts should be promoted. For instance, it was suggested that efforts can be put towards enhancing the farming of edible macroalgae and of filterfeeder organisms (e.g. mussels) that are positive in terms of sustainability (Duarte et al., 2009). However, introducing these new culture species to the Malaysian diet will necessitate influencing consumer preferences (FAO, 2014) which brings its own challenges. It is important to note that Malaysia, being a maritime nation, has a longstanding tradition, culture and habit of fish consumption, hence, the difficulty in modifying their consumption habit can be foreseen. The current perception is that it would be easier to improve the quality and sustainability of the existing species that the people consume.

7.3.2 Reducing Reliance on Fish Meal as Fish Feed

One of the underlying challenges to increasing nutritional reliance on aquaculture is the use of fishmeal in fish feed. This unsustainable practice removes the potential food from the marine ecosystem. Research is needed to develop formulations that are less reliant on fish oil and small fish to provide the PUFA in fish feed. At present, some alternatives have been proposed but are still far from ideal. For instance, alternative marine sources such as krill (Olsen et al., 2006) or calanoid copepods (Olsen et al., 2004) have been proposed but there is a concern over the possible adverse effects of harvesting down the trophic chain (Hill et al., 2006). Microalgae, another aquatic alternative, is still in the development stage and is far more expensive than fish oil (Sprague et al., 2015) due to its low production volume (Vigani et al., 2015). Research Scientists at Crops For the Future (CFF) are investigating the use of black soldier fly larvae as a replacement to fishmeal. Fish feeding trials are promising and more work is underway to explore its scalability and options for commercialisation. However, there is an integral risk to using these replacements: the reduction of fishmeal in fish feed results in a change in the nutritional profile of fish, especially its fatty acid composition.

To reduce reliance on fishmeal while at the same time ensuring farmed fish remains a good source of omega 3 long chain fatty acids, research scientists have turned to genetically modifying

(GM) terrestrial alternatives such as maize and soy to synthesise these beneficial fatty acids that are not normally obtained from plants (Ruiz-Lopez et al., 2014). However, the use of GM plants is a subject of controversy and it is likely that negative public perceptions and attitudes towards GM products will hinder the use of GM oils on a commercial scale. On top of that, maize and soy are not grown in many countries including Malaysia; to import these fishmeal alternatives can be cost prohibitive and increase the carbon footprint, which impacts on the sustainability of the production system. Perhaps it is time to start thinking more strategically outside the box. Since oil palm and coconut are prime sources of vegetable oil used in daily cooking in Malaysia, research could look into genetically modifying these two local plants to provide omega 3. This potential invention is one trophic level less and is theoretically more efficient than using farmed fish as the vehicle to transfer omega 3 fatty acids from GM maize and soy to the human body.

It is important for future governmental policies and industrial effort to consider the nutritional quality of farmed fish to avoid a repetition of events in Bangladesh. Bangladeshis are consuming 30% more fish now than 20 years ago, but malnutrition still persists as the amount of important micronutrients obtained from fish consumption has decreased (Bogard et al., 2017). This is due to the change in types of fish available for consumption. In Bangladesh, wild captured fisheries are declining while aquaculture has been rapidly expanding since its introduction in the 1980s (Belton et al., 2014). Bangladesh is now the world's sixth largest producer of aquaculture products (FAO, 2016). Capture fisheries in the country are dominated by "small indigenous fish" (Hossain and Wahab, 2011), which are rich sources of important micronutrients as they are often consumed whole, including head and bones. Aquaculture, on the other hand, is dominated by large fish species with plenty of flesh (Department of Fisheries Bangladesh, 2014) that provide high quality protein but are poor sources of micronutrient as they cannot be eaten whole. Therefore, as the Bangladeshi diet shifts towards increased consumption of farmed fish, micronutrient intakes from fish have declined. This leads to the question, how has and how would the transition from capture fisheries to aquaculture affect nutrient intakes in Malaysia? The scale of this transition and its implications for nutrient supply and associated nutrition outcomes have never been projected or examined empirically in Malaysia and certainly demand research attention.

7.3.3 Establishing Sustainable Dietary Guidelines

Apart from nutritional consequences, there is also a need for the Ministry of Health Malaysia in collaboration with other stakeholders, to re-examine the dietary guideline in terms of health risk and sustainability indicators. The Mediterranean diet for example, with an abundance of olive oil, fruit, vegetables, cereals, and low quantities of meat and dairy, is a sustainable diet (in the

Mediterranean region) that does not only offer considerable health benefits but is also environmental friendly (Sáez-Almendros et al., 2013). On average, followers of the Mediterranean diet consume an average of 13.5 kg/year fish (van Dooren et al., 2014), which is significantly less than the Malaysian average of 36.9 to 51.9 kg/year. In addition, health concerns related to the consumption of toxic substances, such as heavy metals and organochlorine contaminants above the maximum safety level, has not been addressed in Malaysia at a policy level and should be a concern among policy makers when stipulating the dietary guideline of at least one serving of fish a day. If sustainability is not integrated as part of the long term assessment of the populations diet, today's policies could become the very cause of food insecurity in the future (Berry et al., 2015).

The major challenge to review the dietary guideline for fish consumption from an environmental and health sustainability approach lies within the literature, which is fragmented and sometimes in conflict because nutritional, ecological or economic aspects of a population's diet are usually studied separately (Lang, 2009; Oken et al., 2012). There is a need to have a wider and more comprehensive analysis of Malaysian fisheries with collective efforts from all relevant stakeholders in order to have a complete understanding of the environmental consequences of Malaysian fish consumption. Agreements with industry players should be established to obtain data that is essential for the assessment of sustainability. For example, more data is required to cover the knowledge gap related to production, processing, transportation and food packaging and labelling and that allow the comparison of fishing gears and products of capture fisheries. Aquaculture, on the other hand, has a knowledge gap in terms of the environmental impacts of many different aquaculture production systems. Combining these data with research on the nutritional and health impacts, a fish consumption guideline that respects environmental and health sustainability can be established.

Although reductions in meat consumption and energy intake were identified as main factors for reducing diet-related greenhouse gas emissions (GHGEs), however, the choice of meat replacement foods is crucial, with some foods possibly leading to an increase in GHGEs when energy loss is balanced (Perignon et al., 2017). Also, the framing of the dietary alternatives in the sustainable diets literature must not overlook the unique disease patterning in developing countries characterised by an increasing "triple burden" of undernutrition and diet-related non-communicable illness. The diets of most poor households can be dominated by energy-dense-nutrient-poor foods, not necessarily by choice, but because of the low price and high palatability of such products. Therefore, a different set of dietary alternatives may be needed to enhance sustainability while maintaining the nutritional quality of diets of communities in the pockets of poverty.

The consumers' dietary choices are one of the determinants for sustainability of food systems. Modification of dietary habit based on sustainability indicators can bring about a positive impact to the environment (Pelletier et al., 2011). As we have seen, with the high segmentation of consumers in Chapter 2, it is suggested that different modification strategies be employed in different contexts to suit the situational demand. It is generally thought that "tools" that deliver details about how fish was produced can help consumers to make responsible choices (Verbeke, 2005). Since food traditions and habit vary, it is necessary to adapt the "tools" according to differences related to geographical, economic, and cultural factors. However, the provision of informative tools does not necessarily mean more sustainable consumption among consumers, because Verbeke et al. (2007) found that motivation and knowledge about fish production are not always sufficient to shape attitudes and behaviours. It is apparent that taste or price (Chapter 5) are more effective than environmental messages when approaching Malaysian consumers. The best possible solution is striking a balance between price and sustainability of fish.

7.3.4 Relationship to Previous and Future Research

The project approach is novel and original both in terms of the nature of the research questions being addressed and the methodologies employed. To date, the sustainability of fish consumption habit has not been readily combined with industrial market research surveys and consumer behaviour research.

To the best of author's knowledge, only one of the few food consumption studies in Malaysia focused specifically on fish consumption (Ahmad et al., 2016). In 2008, Ahmad et al. (2016) conducted a cross-sectional survey to investigate patterns of fish consumption among Malaysian adults in Peninsular Malaysia using a 3-day prospective food diary (Ahmad et al., 2016). The study subjects (n= 2675) comprised 14.7% Chinese, 8.3% Indian and 77% Malay. Overall, the subjects consumed 168 g/day (61.3 kg/year) of fish (Ahmad et al., 2016). Those who resided in the Central region (i.e. Klang Valley, Selangor and Negeri Sembilan) consumed 147g/day (53.7kg/year) of fish (Ahmad et al., 2016). In comparison, the average per capita fish consumption in the current study is 51.9kg/year in coastal, 51.8kg/year in rural areas, and 36.9kg/year in urban areas. This study only included data from the Klang Valley, not Negeri Sembilan (which is less urbanised hence higher fish consumption) and had much lower proportion of Malay respondents, which could explain the differences in estimated per capita fish consumption. Although Ahmad et al. (2016) managed to produce a list of ten most frequently consumed marine fish from their surveys, it is not as reliable because the questionnaire was self-administered across all research settings (i.e. rural and urban), hence, there was a high tendency of reporting error. The limitation of this study was the poor response to the type of fish consumed because 40% of the fish consumption records did not mention the fish by name. Therefore, the calculation for fish consumption data were only included in the total fish consumption but not species specific. The researchers identified that this data deficiency might be due to the inability of the study subjects to recall fish name. Mis-reporters were also not identified and energy-adjustment was not made.

The author can confirm that no local study has been conducted to investigate the sustainability of the Malaysian consumption habit. To date, and to the best of the present authors' knowledge, only two studies (one Portuguese and one Dutch) were found to assess the sustainability of fish consumption patterns. Almeida (2014) gathered Portuguese seafood consumption from official statistics and existing literature. Then, a life cycle assessment was conducted to evaluate the consequences for the environment. On the other hand, Seves et al. (2016) aimed to evaluate wild and cultivated fish species consumed in the Netherlands from the combined perspective of n-3 LC-PUFA content and the selected environmental indicators. Seves et al. (2016) assessed fish consumption on two non-consecutive days by 24-hour recalls in the Dutch National Food Consumption Survey 2007–2010. Fish products consumed were classified according to species and types of fishery. Greenhouse gas emissions (GHGE) were evaluated and land use, calculated via life cycle assessments. Fish stocks and biodiversity were taken into account via sustainability labels. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) contents in fish were calculated based on analyses available from food composition databases and literature. By analysing real self-selected diets, both current study and Seves et al. (2016) allowed observation of the variety of real food choices rather than theoretical dietary patterns and, thus, better consideration of the critical dimension of sustainability. This current study relied on several fish stocks statistics as indicators for environmental sustainability instead of GHGE and life cycle assessment. Due to the limitation of data, the researcher had to make do with the available data in the literature.

On the other hand, social science studies of aquaculture have generated increasing interest in recent years. Most of this research has focused on consumer attitudes towards aquaculture products (Verbeke et al., 2005; Verbeke and Vackier 2005; Verbeke et al., 2007; Vanhonacker et al., 2011; Hall and Amberg, 2013; Schlag and Ystgaard, 2013; Claret et al., 2014) and are focused on the main consumer markets of United States of America and European Union. Current research is unique as it is the first attempt to do so in Malaysia. Similar to the findings of the current study, the consumer’s perception of fish as a healthy part of the human diet was consistently confirmed while there is a gap between scientific evidence and consumer perceptions for the health character and nutritional value of fish. What differentiates Malaysian consumers from those of the developed countries is that they have low awareness and understanding of the meaning of a sustainable diet.

Malaysian consumers are considerably more keen on learning the "health risks" (whether scientifically supported or not) related to the consumption of certain food.

The surveys conducted in this research have offered a snapshot insight into the fish consumption habits and perceptions towards farmed fish of consumers in the most populous region in Malaysia at one particular time. It is far from a finished work of the whole of Malaysia, but does give an indication of trends, behaviours, perceptions and concerns of a diverse group of people, who could represent the wider population. Nonetheless, it would be more convincing to have similar surveys conducted nationwide and all the more interesting to combine these findings with other methods. It should be stressed that although there is not a concrete definition and indicators for sustainable consumption and production of fish, it is a concept that needs to be adapted to different contexts and continuous changes (Almeida, 2014). Combining results from different research methods can give a more comprehensive perspective about the food habits and perceptions. Investigation of indirect indicators of fish consumption habits, for example restaurants menus, can also be very useful. Restaurant menus document fish consumption patterns and potentially the availability and value of different species over time, representing a new data source with the potential to fill existing knowledge gaps and measure long-term ecosystem changes (van Houtan et al., 2013).

A sustainable use of marine resources requires effort in two directions: production and consumption. This thesis has been a first known attempt to put Malaysian fish consumption habits into both perspectives and a small contribution helping to understand current and potential barriers of farmed fish in replacing wild-caught ones in the Malaysian diet. Although the research was only conducted in Klang Valley and Selangor, the findings can be extrapolated with care. It can also serve as a baseline case study for similar research to be carried out at other regions. This thesis is instrumental in addressing the research gaps of the FishPLUS programme of CFF. The intended outcome of FishPLUS is for high quality, under-utilised plant-based aquaculture feed (PBAF) to be in abundant supply and used widely in targeted ASEAN countries to partially or completely replace the ingredients currently obtained from major crop species and fishmeal. With this thesis, FishPLUS can better design PBAFs that cater to the nutritional needs and concerns of the population. As a future extension to the current work, a more sensitive dietary assessment tool should be developed to quantify not just the macronutrient intake from different fish types but also the micronutrients derived from fish consumption that was not assessed in the current study. Future extensions should also include systematic sampling and laboratory analysis to supplement the current Malaysian food composition database with the fatty acid profiles and micronutrient content in commonly consumed fish and to assess the level of toxicants in order to be able to propose safety guidelines for fish consumption.

The author recognises the challenges in implementing interdisciplinary approaches. It is crucial for future research to acknowledge the underlying conceptual framework that guides methodological decisions and their inherent assumptions and limitations. For example, if the main objective is for sustainability of diet to gain sufficient political attention as to become a core priority in the shaping of agriculture, food, and nutrition policies, the research must better reflect the diverse characterisation of sustainability. Integrating environmental, health, and social considerations across a multitude of scales and contexts can offer a more complete understanding of the opportunities and barriers to achieving more sustainable diets. Given the potential incompatibility of sustainable diet dimensions, future research on mitigation of the environmental impact of diet should adopt a holistic interdisciplinary approach that integrates the assessment of nutritional adequacy, health impact, acceptability, affordability, and different environmental footprints. In particular, more research on the types of dietary changes that consumers are willing to consider and on methodologies or indicators that allow better assessment of the dimension of acceptability would help to identify more realistic alternative diets.

In closing, a sustainable diet is defined as a "diet with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations" (FAO, 2010). Fish is just one element of the whole diet – a sustainable diet should consider the environmental impacts and the contributions of all components of the diet to improving food and nutrition security and healthier life (Burlingame and Dernini 2012). Promoting a sustainable diet does not mean setting up a common eating pattern for all. Rather than providing consumers with one prescriptive list of recommended foods to be consumed for optimal health, they should be given broad guidelines based on local and seasonal variability. The Mediterranean diet for instance, although highly prized as a sustainable diet, is only deemed to be environmental friendly when consumed in the Mediterranean region where its food components grow. Likewise, a sustainable diet in Malaysia would be based on local produce. Diversification of the diet using local produce is one route to ensure nutrition security and sustainability (Guyomard et al., 2012). The general recommendation for a healthy and sustainable diet is in broad alignment with partial replacement of animal protein with lower-fat plant-based food (Godfray et al., 2010; Garnett, 2011; Macdiarmid et al., 2012; Tilman and Clark, 2014). Adoption of those positive habits, coupled with increased knowledge on the impacts from various fish production systems, would warrant the sustainability of food consumption and production in Malaysia.

REFERENCES

Abd Aziz, N., Azlan, A., Ismail, A., Alinafiah, S.M. and Razman, M.R. (2013) Quantitative determination of fatty acids in marine fish and shellfish from warm water of straits of Malacca for nutraceutical purposes. BioMed Research International. Article 284329.

Abd Aziz, W.N.A.W., Ahmad, F., Hanif, N.R. and Kok, W.H. (2011). Pembasmian Kemiskinan Bandar ke arah Bandar Inklusif dan Sejahtera: Cabaran Kuala Lumpur. J. Surv. Constr. Property, 2: 107-124.

Abd Rahnan, S., Huah, T. S., Nassan, O., & Daud, N. M. (1995). Fatty acid composition of some Malaysian freshwater fish. *Food chemistry*, *54*(1), 45-49.

Abdul Majid, S. (1985) Controlling fishing effort: Malaysia's experience and problems. pp. 215-470 In Papers presented at the Expert Consultation on the regulation of fishing effort (fishing mortality). FAO Fisheries Report No. 298 Supplement 3. Food and Agriculture Organization of the United Nations (FAO), Rome.

Abdul Manan, W., Nur Firdaus, I., Safiah, M.Y., Siti Haslinda, M.D., Poh, B.K., Norimah, A.K., Azmi, M.Y., Tahir, A., Mirnalini, K., Zalilah, M.S., Fatimah, S., Siti Norazlin, M.N. and Fasiah, W. (2012). Meal Patterns of Malaysian Adults: Findings from the Malaysian Adults Nutrition Survey (MANS). Mal J Nutr 18(2):221 -230.

Abu Bakar, I., Ayob, M.K., Abdullah Sani, N. (2013). Fresh water aquaculture fish consumption in Malaysia and heavy metals risk exposure to consumers. Meeting future food demands: security and sustainability.

Abu Talib, A., Salim, K., Chee, P.E., Isa, M.M. and Lim, C.F. (2003). An overview of the socioeconomic status of fisheries in Malaysia. pp. 517-542

Ackman, R. G., Dale, J., & Hingley, J. (1966). Deposition of dimethyl-β-propiothetin in Atlantic cod during feeding experiments. *Journal of the Fisheries Board of Canada*, *23*(4), 487-497.

Ackman, R. G., & Hingley, H. J. (1968). The occurrence and retention of dimethyl-β-propiothetin in some filter-feeding organisms. *Journal of the Fisheries Board of*

Ackman, R. G., Hingley, J., & MacKay, K. T. (1972). Dimethyl sulfide as an odor component in Nova Scotia fall mackerel. Journal of the Fisheries Board of Canada, 29(7), 1085-1088. Canada, *25*(2), 267-284.

Agusa, T., Kunito, T., Sudaryanto, A., Monirith, I., Kan-Atireklap, S., Iwata, H., Ismail, A., Sanguansin, J., Muchtar, M., Tana, T.S., Tanabe, S. (2007). Exposure assessment for trace elements from consumption of marine fish in Southeast Asia. Environmental Pollution Volume 145, Issue 3, February 2007, Pages 766–777.

AHA (2016). Fish and Omega-3 Fatty Acids. Retrieved from: http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/HealthyDietGoals/Fish-and-Omega-3-Fatty-Acids_UCM_303248_Article.jsp#.WdGPJfOGPIU

Ahmad, A.J. (2011). Reorient Health Services [PowerPoint slides]. Retrieved from www.infosihat.gov.my/infosihat/isusemasa/power%20point/ReorientHealthSvcs.pptx

Ahmad, N. I., Noh, M. F. M., Mahiyuddin, W. R. W., Jaafar, H., Ishak, I., Azmi, W. N. F. W., ... & Hairi, M. H. (2015). Mercury levels of marine fish commonly consumed in Peninsular Malaysia. *Environmental Science and Pollution Research*, *22*(5), 3672-3686.

Ahmad, N. I., Wan Mahiyuddin, W. R., Tengku Mohamad, T. R., Ling, C. Y., Daud, S. F., Hussein, N. C., ... and Sulaiman, L. H. (2016). Fish consumption pattern among adults of different ethnics in Peninsular Malaysia. Food and nutrition research, 60(1), 32697.

Ahmed, A. F., Mohamed, Z., and Ismail, M. M. (2011). Determinants of Fresh Fish Purchasing Behavior Among Malaysian Consumers. Current Research Journal of Social Sciences, 3(2), 126–131.

Akbaraly, T. N., and Brunner, E. J. (2008). Socio-demographic influences on trends of fish consumption during later adult life in the Whitehall II study. British Journal of Nutrition, 100(5), 1116–1127. doi:10.1017/S0007114508971312

Alasalvar, C., Taylor, K. D. A., Zubcov, E., Shahidi, F., & Alexis, M. (2002). Differentiation of cultured and wild sea bass (Dicentrarchus labrax): total lipid content, fatty acid and trace mineral composition. *Food chemistry*, *79*(2), 145-150.

Alasalvar, C., Taylor, K. A., & Shahidi, F. (2005). Comparison of volatiles of cultured and wild sea bream (Sparus aurata) during storage in ice by dynamic headspace analysis/gas chromatography–mass spectrometry. *Journal of agricultural and food chemistry*, *53*(7), 2616-2622.

Alavanja, M. C., Hoppin, J. A., & Kamel, F. (2004). Health effects of chronic pesticide exposure: cancer and neurotoxicity* 3. *Annu. Rev. Public Health*, *25*, 155-197.

Álvarez, V., Trigo, M., Lois, S., Fernández, D., Medina, I., & Aubourg, S. P. (2009). Comparative Lipid Composition Study in Farmed and Wild Blackspot Seabream (Pagellus bogaraveo). *CZECH JOURNAL OF FOOD SCIENCES*, *27*, S274-S276.

Alba, T. T. (2015) Study of intertidal mollusc communities in a contaminated mangrove (Navotas, Manila bay) to determinate which species can act as bioindicators of polluted mangroves.

Ali, N., and Abdullah, M. A. (2012). The consumption and eating behaviour of Malaysian urbanites: Issues and concerns. Malaysia Journal of Society and Space, 8(6), 157–165.

Alina, M., Azrina, A., Mohd Yunus, A. S., Mohd Zakiuddin, S., Mohd Izuan Effendi, H., & Muhammad Rizal, R. (2012). Heavy metals (mercury, arsenic, cadmium, plumbum) in selected marine fish and shellfish along the Straits of Malacca. *International Food Research Journal*, *19*(1).

Alleyne, G., Binagwaho, A., Haines, A., Jahan, S., Nugent, R., Rojhani, A., Stuckler, D.; Lancet NCD Action Group (2013). Embedding non-communicable diseases in the post-2015 development agenda. Lancet 2013;381:566–74.

Almeida, C. P. (2014). Seafood consumption in Portugal: Patterns, drivers and sustainability.

Andersen, U. B., Thomassen, M. S., & Rørå, A. M. B. (1997). Texture properties of farmed rainbow trout (Oncorhynchus mykiss): effects of diet, muscle fat content and time of storage on ice. *Journal of the Science of Food and Agriculture*, *74*(3), 347-353.

Andrews, J. (2013, September 11). Formaldehyde Detected in Supermarket Fish Imported from Asia. Food Safety News. Retrieved from: http://www.foodsafetynews.com/2013/09/formaldehyde-detected-in-supermarket-fish-imported-from-asia/#.WdhCG_OGPIU

Anon. (2015, October 1) Impose curbs on sale of formalin. Daily Express. Retrieved from: http://www.dailyexpress.com.my/news.cfm?NewsID=103520

Arechavala-Lopez, P., Fernandez-Jover, D., Black, K. D., Ladoukakis, E., Bayle-Sempere, J. T., Sanchez-Jerez, P., & Dempster, T. (2013). Differentiating the wild or farmed origin of Mediterranean fish: a review of tools for sea bream and sea bass. *Reviews in Aquaculture*, *5*(3), 137-157.

ASEAN (2016). ASEAN Statistics Leaflet – Selected Key Indicators 2016. Retrieved from: http://www.aseanstats.org/publication/asean-statistics-leaflet-selected-key-indicators-2016/

ASEAN-SEAFDEC (2016). Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating Illegal, Unreported and Unregulated (IUU) Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products. Retrieved from: http://www.seafdec.org/documents/hlc-joint-declaration.pdf

Aston, L.M., Smith, J. N. and Powles, J.W. (2012). Impact of a reduced red and processed meat dietary pattern on disease risks and greenhouse gas emissions in the UK: a modelling study. BMJ Open, 2(5).

Aursand, M. and Axelson, D. (2001) Origin recognition of wild and farmed salmon (Norway and Scotland) using 13C NMR spectroscopy in combination with pattern recognition techniques. In: Magnetic Resonance in Food Science: A View to the Future. Webb, G.A., Belton, P.S., Gil, A.M. and Delgadillo, I. (Eds.). Published by RSC-The Royal Society of Chemistry, pp. 227-231.

Aursand, M., Bleivik, B., Rainuzzo, J.R., Jørgensen, L. and Mohr, V. (1994) Lipid distribution and composition of commercially farmed Atlantic salmon (Salmo salar). J. Sci. Food Agric., 64: 239-248.

Aursand, M., Mabon, F. and Martin, G.J. (2000) Characterization of farmed and wild salmon (Salmo salar) by a combined use of compositional and isotopic analyses. JAOCS., 77: 659-666.

Azam, K., Mackie, I. M., & Smith, J. (1989). The effect of slaughter method on the quality of rainbow trout (Salmo gairdneri) during storage on ice. *International Journal of Food Science & Technology*, *24*(1), 69-79.

Azlan, A., Nasir, N. N. M., Razman, M. R., Ramli, N. A., & Latiff, A. A. (2011). Dioxins and furans in demersal fish and shellfish from regions in west coast Peninsular Malaysia. *J Food Agric Environ*, *9*(2), 72-78.

Azlan, A., Nasir, N. N. M., Shamsudin, N., Rahman, H. A., Khoo, H. E., & Razman, M. R. (2015). PCDD and PCDF exposures among fishing community through intake of fish and shellfish from the Straits of Malacca. *BMC public health*, *15*(1), 683.

Babcock, B.A. and Weninger, Q. (2004). "Can Quality Revitalize the Alaskan Salmon Industry?," Center for Agricultural and Rural Development (CARD) Publications 04-wp359, Center for Agricultural and Rural Development (CARD) at Iowa State University.

Bacher, K. (2015). Perceptions and misconceptions of aquaculture: a global overview. Rome, Italy: Food and Agriculture Organization of the United Nations; Report No: 120.

Bach-Faig, A., Berry, E. M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., ... and Serra-Majem, L. (2011). Mediterranean diet pyramid today. Science and cultural updates. Public health nutrition, 14(12A), 2274-2284.

Bailey, R. L., Gahche, J. J., Lentino, C. V., Dwyer, J. T., Engel, J. S., Thomas, P. R., ... and Picciano, M. F. (2010). Dietary supplement use in the United States, 2003–2006. The Journal of nutrition, jn-110.

Bailey, R. L., Gahche, J. J., Miller, P. E., Thomas, P. R., and Dwyer, J. T. (2013). Why US adults use dietary supplements. JAMA internal medicine, 173(5), 355-361.

BDA (2016). Food Fact Sheets: Healthy Eating. Retrieved from: https://www.bda.uk.com/foodfacts/HealthyEating.pdf

Bell, J.G., McEvoy, J., Tocher, D.R., McGhee, F., Campbell, P.J. and Sargent, J.R. (2001). Replacement of Fish Oil with Rapeseed Oil in Diets of Atlantic Salmon (Salmo salar) Affects Tissue Lipid Compositions and Hepatocyte Fatty Acid Metabolism. The Journal of Nutrition, 131(5), pp. 1535-1543.

Belton, B., van Asseldonk, I. J. M., and Thilsted, S. H. (2014). Faltering fisheries and ascendant aquaculture: Implications for food and nutrition security in Bangladesh. Food Policy, 44, 77-87.

Berry, E. M., Dernini, S., Burlingame, B., Meybeck, A., and Conforti, P. (2015). Food security and sustainability: can one exist without the other?. Public health nutrition, 18(13), 2293-2302.

Bhouri, A. M., Bouhlel, I., Chouba, L., Hammami, M., El Cafsi, M., & Chaouch, A. (2010). Total lipid content, fatty acid and mineral compositions of muscles and liver in wild and farmed sea bass (Dicentrarchus labrax). *African Journal of Food Science*, *4*(8), 522-530.

Bingham, S.A. (1994). The use of 24-h urine samples and energy expenditure to validate dietary assessments. Am. J. Clin. Nutr., 59, (Suppl)S227–S231.

Birch, D., and Lawley, M. A. (2010). A Conceptual Framework for Investigating Fish Consumption in Australia. In Conference of the Australian and New Zealand Marketing Academy (pp. 1–10).

Bjerregaard, L. J., Joensen, A. M., Dethlefsen, C., Jensen, M. K., Johnsen, S. P., Tjønneland, A., ... and Schmidt, E. B. (2009). Fish intake and acute coronary syndrome. European heart journal, 31(1), 29-34.

Bjørnevik, M., Karlsen, Ø., Johnston, I. A., & Kiessling, A. (2003). Effect of sustained exercise on white muscle structure and flesh quality in farmed cod (Gadus morhua L.). *Aquaculture Research*, *34*(1), 55-64.

Black, A. E. (2000). The sensitivity and specificity of the Goldberg cut-off for EI: BMR for identifying diet reports of poor validity. European journal of clinical nutrition, 54(5), 395.

Blair, R. (2012). *Organic production and food quality: A down to earth analysis*. John Wiley & Sons.

Bogard, J. R., Farook, S., Marks, G. C., Waid, J., Belton, B., Ali, M., ... and Thilsted, S. H. (2017). Higher fish but lower micronutrient intakes: Temporal changes in fish consumption from capture fisheries and aquaculture in Bangladesh. PloS one, 12(4), e0175098.

Bondad-Reantaso, M.G.; Arthur, J.R.; Subasinghe, R.P. (eds). (2008). Understanding and applying risk analysis in aquaculture. FAO Fisheries and Aquaculture Technical Paper. No. 519. Rome, FAO. 2008. 304p.

Borderías, A. J., and Sánchez-Alonso, I. (2011). First Processing Steps and the Quality of Wild and Farmed Fish. Journal of Food Science, 76(1), R1–R5. http://doi.org/10.1111/j.1750-3841.2010.01900.x

Bouis, H. E., Eozenou, P., and Rahman, A. (2011). Food prices, household income, and resource allocation: socioeconomic perspectives on their effects on dietary quality and nutritional status. Food and nutrition bulletin, 32(1_suppl1), S14-S23.

Boyd, N. S., Wilson, N. D., Jerrett, A. R., and Hall, B. I. (1984). Effects of brain destruction on post harvest muscle metabolism in the fish kahawai (Arripis trutta). Journal of Food Science, 49(1), 177-179.

Brantsæter, A. L., Haugen, M., Thomassen, Y., Ellingsen, D. G., Ydersbond, T. A., Hagve, T. A., ... and Meltzer, H. M. (2010). Exploration of biomarkers for total fish intake in pregnant Norwegian women. Public health nutrition, 13(1), 54-62.

Bremner, H.A. (1992) Fish flesh structure and the role of collagen – its post-mortem aspects and implications for fish processing. In: Quality Assurance in the Fish Industry (ed. by H.H.Huss, M.Jakobsen and J.Liston), pp. 39–62. Elsevier Science Publishers, Amsterdam.

Britton, G., Liaaen-Jensen, S. and Pfander, H. (2009). Carotenoids: Nutrition and Health. Birkhauser Verlag. US.

Broughton, N. M., & Goldspink, G. (1978). Biochemical changes in the lateral muscles of roach, Rutilus rutilus from two habitats following exercise. *Journal of Fish Biology*, *13*(5), 613-618.

Burke, B.S. (1947). The dietary history as a tool in research. J Am Diet Assoc. 1947;23:1041-1046.

Burlingame, B. and Dernini, S. (2012) Sustainable diets and biodiversity: directions and solutions for policy, research and action. Proceedings of the International Scientific Symposium on Biodiversity and Sustainable Diets: United Against Hunger; 2010 Nov 3–5; Rome. Rome: Food and Agriculture Organization

Caballero, B. (2009). Guide to Nutritional Supplement. Elsevier Ltd. UK.

Cade, J., Thompson, R., Burley, V., and Warm, D. (2002). Development, validation and utilisation of food-frequency questionnaires–a review. Public health nutrition, 5(4), 567-587.

Cahu, C., Salen, P., and de Lorgeril, M. (2004). Farmed and wild fish in the prevention of cardiovascular diseases: Assessing possible differences in lipid nutritional values. Nutrition, Metabolism and Cardiovascular Diseases, 14(1), 34–41. doi:http://dx.doi.org/10.1016/S0939-4753(04)80045-0

Can, M. F., Günlü, A., and Can, H. Y. (2015). Fish consumption preferences and factors influencing it. Food Science and Technology (Campinas), 35(2), 339-346.

Canada. (2011). Market Analysis Report: The Malaysian Consumer Behaviour, Attitudes and Perceptions Toward Food Products. International Markets Bureau.

CAP (2011) Consumer Association of Penang. Ban trawl fishing now to prevent the collapse of our fisheries. Retrieved from: https://www.consumer.org.my/index.php/development/environment/506-ban-trawl-fishing-now-to-prevent-the-collapse-of-our-fisheries

Carpenter, K. J. (2003a). A short history of nutritional science: Part 1 (1785–1885). The Journal of nutrition, 133(3), 638-645.

Carpenter, K. J. (2003b). A short history of nutritional science: part 2 (1885–1912). The Journal of nutrition, 133(4), 975-984.

Carpenter, K. J. (2003c). A short history of nutritional science: part 3 (1912–1944). The Journal of nutrition, 133(10), 3023-3032.

Carpenter, K. J. (2003d). A short history of nutritional science: part 4 (1945–1985). The Journal of nutrition, 133(11), 3331-3342.

CFF (2015). What does CFF Research focus on? Retrieved from: http://www.cffresearch.org/Our_Research-@-LandingArticle.aspx#sthash.LzbXbVQ6.dpbs

Chamhuri, N., and Batt, P. J. (2013). Exploring the factors influencing consumers' choice of retail store when purchasing fresh meat in Malaysia. International Food and Agribusiness Management Review, 16(3), 99-122.

Chandralekha, A.P.L., Baranage, C. and Samarajeewa, U. (1992) Formaldehyde levels in fish from the Kandy market. Journal of the National Science Foundation of Sri Lanka, 20, 115–121.

Cheung, W. W., Jones, M. C., Reygondeau, G., Stock, C. A., Lam, V. W., and Frölicher, T. L. (2016). Structural uncertainty in projecting global fisheries catches under climate change. Ecological Modelling, 325, 57-66.

Cheung, W. W., Sarmiento, J. L., Dunne, J., Frölicher, T. L., Lam, V. W., Palomares, M. D., ... and Pauly, D. (2013). Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems. Nature Climate Change, 3(3), 254.

Claret, A., Guerrero, L., Ginés, R., Grau, A., Hernández, M. D., Aguirre, E., … Rodríguez-Rodríguez, C. (2014). Consumer beliefs regarding farmed versus wild fish. Appetite, 79, 25–31. doi:http://dx.doi.org/10.1016/j.appet.2014.03.031

Cock, J., Salazar, M., & Rye, M. (2015). Strategies for managing diseases in non-native shrimp populations. *Reviews in Aquaculture*.

Codex Alimentarius Commission (2006). Code of Practice for the Prevention and Reduction of Dioxin and Dioxin-like PCB Contamination in Foods and Feeds [Internet]. Codex Alimentarius: International Foods Standards; 2006. Available from http://www.codexalimentarius.org/input/download/standards/10693/CXP_062e.pdf.

Coulston, A.M., Boushey, C.J., and Ferruzzi, M.G. (2013) In Nutrition in the Prevention and Treatment of Disease (Third Edition), Academic Press, 2013, Page 9, ISBN 9780123918840, http://dx.doi.org/10.1016/B978-0-12-391884-0.00050-0.

Craig, S., & Helfrich, L. A. (2009). Understanding fish nutrition, feeds, and feeding.

Creswell, J. W., & Plano Clark, V. L. (2011). Designing and Conducting Mixed Methods Research (2nd ed.). London: Sage Publications Ltd.

Cretì, P., Trinchella, F., & Scudiero, R. (2010). Heavy metal bioaccumulation and metallothionein content in tissues of the sea bream Sparus aurata from three different fish farming systems. *Environmental monitoring and assessment*, *165*(1-4), 321-329.

Darko, F. A., Quagrainie, K. K., and Chenyambuga, S. (2016). Consumer preferences for farmed tilapia in Tanzania: A choice experiment analysis. Journal of Applied Aquaculture, 28(3), 131–143. doi:10.1080/10454438.2016.1169965

Davidson, W., and Goldspink, G. (1977). The effect of prolonged exercise on the lateral musculature of the brown trout (Salmo trutta). *Journal of Experimental Biology*, *70*(1), 1-12.

De Silva, S. S., and Soto, D. (2009). Climate change and aquaculture: potential impacts, adaptation and mitigation. Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper, 530, 151-212.

Defrancesco, E. (2003). The Beginning of Organic Fish Farming in Italy, TeSAF Department, University of Padova, Italy.

Department of Fisheries Bangladesh (2014). Fisheries Statistical Yearbook of Bangladesh. Fisheries Resources Survey System (FRSS), Volume 30: 52 p.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. and El Bilali, H. (2013). Developing a methodological approach for assessing the sustainability of diets: The Mediterranean diet as a case study. New Medit, 12(3): 28-37

Dionigi, C. P., Johnsen, P. B., & Vinyard, B. T. (2000). The recovery of flavor quality by channel catfish. *North American Journal of Aquaculture*, *62*(3), 189-194.

Doak, C. M., Adair, L. S., Bentley, M., Monteiro, C., and Popkin, B. M. (2005). The dual burden household and the nutrition transition paradox. International journal of obesity, 29(1), 129.

DoFM (2000 – 2014). National annual fisheries statistics were obtained from official spreadsheets and reports uploaded by the Department of Fisheries, Malaysia on its open data portal:http://www.dof.gov.my/index.php/pages/view/82

DoFM (2015) National plan of action for the management if fishing capacity in Malaysia. (Plan 2) ISBN 978-967-0633-07-7 1. Fishing--Malaysia. 639.209595

Donini, L. M., Dernini, S., Lairon, D., Serra-Majem, L., Amiot, M. J., del Balzo, V., ... and Polito, A. (2016). A consensus proposal for nutritional indicators to assess the sustainability of a healthy diet: the mediterranean diet as a case study. Frontiers in nutrition, 3.

DoSM (2016). National demographics and socio-economic data were obtained from official spreadsheets and reports uploaded by the Department of Statistics, Malaysia on its open data portal: https://www.dosm.gov.my/v1/index.php?r=column3/accordionandmenu_id=aHhRYUpWS3B4VXlYaVBOeUF0WFpWUT09

Drastini, Y. and Widiasihl, D.A. (2009) Studies on Schiff method for the detection formaldehyde in marine milk fish (Chanos-chanos). Journal of Sains Veterinary, 27, 21–27.

Drewnowski, A. (2005). Concept of a nutritious food: toward a nutrient density score. Am J Clin Nutr. 2005; 82: 721–732.

Duarte, C.M., Holmer, M., Olsen, Y., Soto, D., Marbà, N., Guiu, J., Black, K. and Karakassis, I. (2009). Will the oceans help feed humanity? BioScience, 59(11): 967-976

Dunajski, E. (1980). Texture of fish muscle. *Journal of Texture Studies*, *10*(4), 301-318.

EFSA (2005). Opinion on the scientific panel on contaminants in the food chain on a request from the European Parliament related to the safety assessment of wild and farmed fish. *EFSA J*, *236*, 1-118.

Einen, O., & Thomassen, M. S. (1998). Starvation prior to slaughter in Atlantic salmon (Salmo salar): II. White muscle composition and evaluation of freshness, texture and colour characteristics in raw and cooked fillets. *Aquaculture*, *169*(1), 37-53.

Elhadary, Y.A.E. and N. Samat (2012). Political economy and urban poverty in the developing countries: Lessons learned from Sudan and Malaysia. J. Geogr. Geol., 4: 212-223.

Elmadfa, I., & Meyer, A. L. (2014). Developing Suitable Methods of Nutritional Status Assessment: A Continuous Challenge. Advances in Nutrition, 5(5), 590S–598S.

Eltholth, M., Fornace, K., Grace, D., Rushton, J., and Häsler, B. (2015). Characterisation of production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt. Food Policy, 51, 131-143.

Endinkeau, K. and Tan, K.K. (1993) Profile of Fatty Acid Contents in Malaysian Freshwater Fish, Pertanika J. Trop. Agric. Sci. 16(3): 215-221.

EPU (2017). Malaysia Sustainable Development Goals Voluntary National Review 2017. Putrajaya: Economic Planning Unit, Prime Minister's Department.

EPU (1992). Malaysian National Conservation Strategy Background Paper On The Coastal Zone In Malaysia Processes Issues And Management Plan. Available through: http://repository.wwf.org.my/technical_reports/M/MalaysianNationalConservationStrategyBackgroundPaperOnTheCoastalZoneInMalaysiaProcessesIssuesAndManagementPlan.pdf [Accessed 22 September 2013].

EPU (2015). Eleventh Malaysia Plan. Putrajaya: Economic Planning Unit, Prime Minister's Department.

Fagúndez, L.J.M., Torres, A.R., Sánchez, M.E.G., de Torres Aured, M.L., Rodrigo, C.P. and Rocamora, J.A.I., (2015). Diet history: Method and applications. Nutr Hosp. 2015;31 (Supl. 3):57-61

Fallah, A. A., Saei-Dehkordi, S. S., Nematollahi, A., & Jafari, T. (2011). Comparative study of heavy metal and trace element accumulation in edible tissues of farmed and wild rainbow trout (Oncorhynchus mykiss) using ICP-OES technique. *Microchemical Journal*, *98*(2), 275-279.

FAO (2001) FAO Food Balance Sheets: A Handbook. Food and Agriculture Organization of the United Unions, Rome.

FAO. 2016. The State of World Fisheries and Aquaculture 2002. Food and Agriculture Organization of the United Unions, Rome.

FAO (2003). Measurement and assessment of food deprivation and undernutrition [cited 2017 Feb 22]. Available from: www.fao.org/DOCREP/005/Y4249E/y4249 E00.htm

FAO (2004). Status and potential of fisheries and aquaculture in Asia and the Pacific by Regional Office for Asia and the Pacific Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific. Available through ftp://ftp.fao.org/docrep/fao/009/ag110e/ag110e00.pdf [Accessed 23 September 2013].

FAO (2005). Post-harvest changes in fish. In: FAO Fisheries and Aquaculture Department, Food and Agriculture Organization, Rome, Italy. http://www.fao.org/fishery/topic/12320/en

FAO (2006). The double burden of malnutrition: case studies from six developing countries. Rome: Nutrition Planning, Assessment and Evaluation Service, Food and Agriculture Organization of the United Nations.

FAO (2008 - 2017) National Aquaculture Sector Overview. Malaysia. National Aquaculture Sector Overview Fact Sheets. Text by Mazuki Hashim. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 2008.

FAO (2009). Fishery and Aquaculture Country Profiles. Malaysia (2009). Country Profile Fact Sheets. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 1 February 2009. [Cited 3 October 2017].

FAO (2010) Fats and fatty acids in human nutrition: report of an expert consultation. FAO Food and Nutrition Paper 91. Rome: Food and Agriculture Organization of the United Nations; 2010.

FAO (2010). Report of the Regional Workshop on Methods for Aquaculture Policy Analysis, Development and Implementation in Selected Southeast Asian Countries. Bangkok, 9–11 December 2009. FAO Fisheries and Aquaculture Report. No. 928. Rome, FAO. 2010. 45p.

FAO (2012). The state of food insecurity in the world 2012. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition. Rome: Food and Agriculture Organization.

FAO (2013) Food Systems for Better Nutrition. Rome: Food and Agriculture Organization of the United Nations.

FAO (2014). The state of world fisheries and aquaculture 2014 (SOFIA), FAO Fisheries and Aquaculture Department, Rome.

FAO and WHO (2012). Code of Practice for fish and fishery products: Second edition. ISBN 978-92-5-107018-5

FAO Council (1989). The state of food and agriculture 1989. (FAO Agriculture Series, no. 22) ISBN 92-5-102838-9

FAO, IFAD and WFP. (2015). The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome, FAO.

FAO (2015). Mediterranean food consumption patterns: diet, environment, society, economy and health. A White Paper Priority 5 of Feeding Knowledge Programme, Expo Milan 2015. CIHEAM-IAMB, Bari/FAO, Rome.

FAO (2016). The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome. 200 pp

FAO (2017a). Food Balance Sheets for year 1980 to 2013 were downloaded as spreadsheets from: http://faostat.fao.org/site/368/default.aspx#ancor

FAO (2017b). Strengthening capacities, policies and national action plans on prudent and responsible use of antimicrobials in fisheries: Workshop 2 in cooperation with Malaysia Department of Fisheries and INFOFISH (FAO Project FMM/RAS/298). Available at: http://www.fao.org/fi/static-media/MeetingDocuments/Workshop2AMR/presentations/26.pdf

Farmer, L. J., McConnell, J. M., & Kilpatrick, D. J. (2000). Sensory characteristics of farmed and wild Atlantic salmon. *Aquaculture*, *187*(1), 105-125.

FDA (2016) Constituent Update: FDA Issues Import Alert on Imported Shrimp and Prawns from Peninsular Malaysia. Available at https://www.fda.gov/Food/NewsEvents/ConstituentUpdates/ucm496475.htm

Fernald, L.C., Gertler, P.J., Hou, X. (2008). Cash component of conditional cash transfer program is associated with higher body mass index and blood pressure in adults. J Nutr. 2008;138:2250–2257

Fernández-Polanco, J., and Luna, L. (2012). Factors affecting consumers' beliefs about aquaculture. Aquaculture Economics and Management, 16(1), 22–39. doi:10.1080/13657305.2012.649047

Ferreira, M.G., Silva, N.F., Schmidt, F.D., Silva, R.M., Sichieri, R., Guimarães, L.V., Pereira, R.A. (2010). Development of a food frequency questionnaire for adults in a population-based sample in Cuiabá, Mid-Western Region of Brazil. Rev Bras Epidemiol. 2010 Sep;13(3):413-24.

Flos, R., Reig, L., Oca, J., & Ginovart, M. (2002). Influence of marketing and different land-based systems on gilthead sea bream (Sparus aurata) quality. *Aquaculture International*, *10*(3), 189-206.

Foote, J.A., Murphy, S.P., Wilkens, L.R., Hankin, J.H., Henderson, B.E., Kolonel, L.N. (2003). Factors associated with dietary supplement use among healthy adults of five ethnicities: the Multiethnic Cohort Study. Am J Epidemiol. 2003; 157(10):888–897.

Foran, J. A., Hites, R. A., Carpenter, D. O., Hamilton, M. C., Mathews-Amos, A., & Schwager, S. J. (2004). A survey of metals in tissues of farmed Atlantic and wild Pacific salmon. *Environmental toxicology and chemistry*, *23*(9), 2108-2110.

From, J., & Hørlyck, V. (1984). Sites of uptake of geosmin, a cause of earthy-flavor, in rainbow trout (Salmo gairdneri). *Canadian Journal of Fisheries and Aquatic Sciences*, *41*(8), 1224-1226.

Fuentes, A., Fernández-Segovia, I., Serra, J. A., & Barat, J. M. (2010). Comparison of wild and cultured sea bass (Dicentrarchus labrax) quality. *Food Chemistry*, *119*(4), 1514-1518.

Garcia-Alvarez, L., Dawson, S., Cookson, B. and Hawkey, P. (2012). Working across the veterinary and human health sectors. Journal of Antimicrobial Chemotherapy, 67: 37-49.

Garnett, T. (2011). Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)?. *Food policy*, *36*, S23-S32.

Gaviglio, A., and Demartini, E. (2009). Consumer attitudes towards farm-raised and wild-caught fish: Variables of product perception. New Medit, 8(3), 34–40.

Gay, L. R. (1996). Educational Research: Competencies for Analysis and Application. Beverly Hill, CA: Sage Publications.

Gibson, R.S. (2005) Principles of Nutritional Assessment, 2nd ed., pp. 908. New York: Oxford University Press. Pg 111

Githukia, C. M., Obiero, K. O., Manyala, J. O., Ngugi, C. C., and Quagrainie, K. K. (2014). Consumer Perceptions and Preferences of Wild and Farmed Nile Tilapia (Oreochromis niloticus L.) and African Catfish (Clarias gariepinus Burchell 1822) in Urban Centres in Kenya. International Journal of Advanced Research, 2(7), 694–705.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. Science 2010; 327:812–8.

Goldberg, G. R., Black, A. E., Jebb, S. A., Cole, T. J., Murgatroyd, P. R., Coward, W. A., & Prentice, A. M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. European journal of clinical nutrition, 45(12), 569-581.

Golden, C. D., Allison, E. H., Cheung, W. W., Dey, M. M., Halpern, B. S., McCauley, D. J., ... and Myers, S. S. (2016). Fall in fish catch threatens human health. Nature, 534(7607), 317-320.

González, S., Flick, G. J., O'keefe, S. F., Duncan, S. E., McLean, E., & Craig, S. R. (2006). Composition of farmed and wild yellow perch (Perca flavescens). *Journal of Food Composition and Analysis*, *19*(6), 720-726.

Goris, A.H. and Westerterp, K.R. (1999). Underreporting of habitual food intake is explained by undereating in highly motivated lean women. J Nutr 129, 878–882

Government Office for Science (2011). Foresight. The future of food and farming. Final Project Report.

Gram, L., & Dalgaard, P. (2002). Fish spoilage bacteria–problems and solutions. *Current opinion in biotechnology*, *13*(3), 262-266.

Grigorakis, K., Taylor, K. D. A., & Alexis, M. N. (2003). Organoleptic and volatile aroma compounds comparison of wild and cultured gilthead sea bream (Sparus aurata): sensory differences and possible chemical basis. *Aquaculture*, *225*(1), 109-119.

Grigorakis, K., Alexis, M., Gialamas, I., & Nikolopoulou, D. (2004). Sensory, microbiological, and chemical spoilage of cultured common sea bass (Dicentrarchus labrax) stored in ice: a seasonal differentiation. *European Food Research and Technology*, *219*(6), 584-587.

Grigorakis K., (2007). Compositional and organoleptic quality of farmed and wild gilthead sea bream (Sparus aurata) and sea bass (Dicentrarchus labrax) and factors affecting it: A review. Aquaculture 272, 55-75.

Gutierrez, R., Whangchai, N., Sompong, U., Prarom, W., Iwami, N., Itayama, T., ... & Sugiura, N. (2013). Off-flavour in Nile tilapia (Oreochromis niloticus) cultured in an integrated pond-cage culture system. *Maejo International Journal of Science and Technology*, *7*, 1.

Guyomard, H., Darcy-Vrillon, B., Esnouf, C., Marin, M., Momot, A., Russel, M. and Guillou, M. (2012). Eating patterns and food systems: critical knowledge requirements for policy design and implementation. Agriculture and Food Security, 1: 13.

Haard, N.F. (1992). Control of chemical composition and food quality attributes of cultured fish. Food Research International, Vol. 25, pp. 289–307.

Hall, T.E. and Amberg, S.M. (2013). Factors influencing consumption of farmed seafood products in the Pacific northwest. Appetite, 2013 Jul; 66:1-9.

Hall, K. D., Guo, J., Dore, M., & Chow, C. C. (2009). The progressive increase of food waste in America and its environmental impact. PloS one, 4(11), e7940.

Hamilton, M. C., Hites, R. A., Schwager, S. J., Foran, J. A., Knuth, B. A., & Carpenter, D. O. (2005). Lipid composition and contaminants in farmed and wild salmon. *Environmental science & technology*, *39*(22), 8622-8629.

Hanis, I. A. H. A., Jinap, S., Nasir, S. M., and Alias, R. (2013). Eliciting Malaysian Consumer Preferences for Marine Fish Attributes by Using Conjoint Analysis. World Applied Sciences Journal, 28(12), 2054–2060.

Hardy, R. W. (2003). Farmed fish and omega-3 fatty acids. *Aquaculture Magazine*, *29*(2), 63-65.

Harris, J.A., and Benedict, F.G. (1919). A biometric study of basal metabolism in man. publication no 279. Carnegie Institution of Washington: Washington, DC, 1919.

Harvard University (2001). Research Methods: Some Notes to Orient You. (2016). 1st ed. [ebook] Harvard University, pp.5-6. Available at: http://isites.harvard.edu/fs/docs/icb.topic851950.files/Research%20Methods_Some%20Notes.pdf [Accessed 23 October 2013].

Hathurusingha, P. I., & Davey, K. R. (2016). Chemical taste taint accumulation in RAS farmed fish–A Fr 13 risk assessment demonstrated with geosmin (GSM) and 2-methylisoborneol (MIB) in barramundi (Lates calcarifer). *Food Control*, *60*, 309-319.

Hellberg, R. S., DeWitt, C. A. M., & Morrissey, M. T. (2012). Risk‐benefit analysis of seafood consumption: A review. Comprehensive reviews in food science and food safety, 11(5), 490-517.

Henriques, J., Dick, J. R., Tocher, D. R., & Bell, J. G. (2014). Nutritional quality of salmon products available from major retailers in the UK: content and composition of n-3 long-chain PUFA. *British Journal of Nutrition*, *112*(6), 964-975.

Herrero, A. M., Carmona, P., Garcia, M. L., Solas, M. T., & Careche, M. (2005). Ultrastructural changes and structure and mobility of myowater in frozen-stored hake (Merluccius merluccius L.) muscle: relationship with functionality and texture. *Journal of agricultural and food chemistry*, *53*(7), 2558-2566.

Hiç, C., Pradhan, P., Rybski, D., and Kropp, J. P. (2016). Food surplus and its climate burdens. Environmental science and technology, 50(8), 4269-4277.

Hicks, D., Pivarnik, L. and McDermott, R. (2008). Consumer perceptions about seafood–an Internet survey. Journal of Foodservice, 19(4): 213-226.

Hill, S. L., Murphy, E. J., Reid, K., Trathan, P. N. and Constable, A. J. (2006). Modelling Southern Ocean ecosystems: krill, the food-web, and the impacts of harvesting. Biol. Rev. 81, 581–608.

Hites, R. A., Foran, J. A., Carpenter, D. O., Hamilton, M. C., Knuth, B. A., & Schwager, S. J. (2004). Global assessment of organic contaminants in farmed salmon. *Science*, *303*(5655), 226-229.

Hjartaker, A., Lund, E. and Bjerve, K.S. (1997). Serum phospholipid fatty acid composition and habitual intake of marine foods registered by a semi-quantitative food frequency questionnaire. Eur J Clin Nutr 51, 736–742.

Hochachka, P. W. (1961). The effect of physical training on oxygen debt and glycogen reserves in trout. Canadian Journal of Zoology, *39*(6), 767-776.

Holland, B., Brown, J., and Buss, D.H. (1993). Fish and Fish products. Royal Society of Chemistry and Ministry of Agriculture. Fisheries and Food, Cambridge. UK.

Homer, P.M. and Kahle, L.R. (1988). A structural equation test of the value–attitude–behaviour hierarchy. Journal of Personality and Social Psychology, Vol. 54, pp. 638–646.

Hossain, M. A. (2011). Fish as source of n-3 polyunsaturated fatty acids (PUFAs), which one is better-farmed or wild?. *Advance Journal of Food Science and Technology*, *3*(6), 455-466.

Hossain, M. A., and Wahab, M. A. (2011). The Diversity of Cypriniforms Throughout Bangladesh. Nova Science Publishers, Incorporated.

Huidobro, A., and Tejada, M. (2004). Gilthead seabream (Sparus aurata): suitability for freezing and commercial alternatives. J Sci Food Agric. 2004;84:1405–13.

Hunter, B. J., Allan, G. L., & Roberts, D. C. (2001). Lipid composition of farmed versus wild silver perch Bidyanus bidyanus: theoretical impact on a human diet. *Australian Journal of Nutrition and Dietetics*, *58*(1), 45-51.

Huntington, T.C. and Hasan, M.R. (2009). Fish as feed inputs for aquaculture – practices, sustainability and implications: a global synthesis. In M.R. Hasan and M. Halwart (eds). Fish as feed inputs for aquaculture: practices, sustainability and implications. FAO Fisheries and Aquaculture Technical Paper. No. 518. Rome, FAO. pp. 1–61.

Hurlburt, B.K., Brashear, S.S., Lloyd, S.W., Grimm, C.C., Thomson, J.L. and Zimba, P.V. 2009. Impact of weather on off-flavour episodes at a Louisiana commercial catfish farm. Aquaculture Research, 40(5): 566-574.

Huss, H.H. (1995). Quality and quality changes in fresh fish. FAO fisheries technical. Rome: FAO Press; 1995. p. 348.

Hutchings, J.A. (2000). Collapse and recovery of marine fishes. Nature, 406(6798): 882-885.

Hwalla, N., and Koleilat, M. (2004). Dietetic practice: the past, present and future.

Igarashi, T., Aursand, M., Sacchi, R., Paolillo, L., Nonaka, M. and Wada, S. (2002) Determination of docosahexaenoic acid and n-3 fatty acids in refined fish oils by 1 H-NMR spectroscopy: IUPAC interlaboratory study. J. AOAC Int., 85: 1341-1354.

Ikem, A. and Egiebor, N.O. (2005). Assessment of trace elements in canned fishes (mackerel, tuna, salmon, sardines and herrings) marketed in Gergia and Alabama (United States of America). Journal of Food Composition and Analysis, vol. 18, pp. 771 – 787.

Institute of Public Health (2014). National Health and Morbidity Survey 2014 : Malaysian Adult Nutrition Survey (MANS) Vol. II : Survey Findings : 343 pages.

Institute of Public Health (2015). National Health and Morbidity Survey 2015 (NHMS 2015). Vol. II: Non-Communicable Diseases, Risk Factors and Other Health Problems.

Institute of Public Health (2017). Primary data analysis reports for NHMS III (2006), NHMS IV (2011) and NHMS V (2015) were downloaded from: http://www.iku.gov.my/index.php/research-eng/list-of-research-eng/iku-eng/nhms-eng.

Ismail, M.N., Ng, K.K., Chee, S.S., Roslee, R. and Zawiah, H. (1998). Predictive equations for the estimation of basal metabolic rate in Malaysian adults. Mal J Nutr

Ismail, A., Jusoh, N. R., and Ghani, I. A. (1995). Trace metal concentrations in marine prawns off the Malaysian coast. Marine Pollution Bulletin, 31(1), 108–110. doi:http://dx.doi.org/10.1016/0025-326X(95)00080-7

IUCN (1964 – 2017) The IUCN Red List of Threatened Species. Available from: http://www.iucnredlist.org/

Izquierdo, M. S., Obach, A., Arantzamendi, L., Montero, D., Robaina, L., & Rosenlund, G. (2003). Dietary lipid sources for seabream and seabass: growth performance, tissue composition and flesh quality. *Aquaculture nutrition*, *9*(6), 397-407.

Izquierdo, M. S., Montero, D., Robaina, L., Caballero, M. J., Rosenlund, G., & Ginés, R. (2005). Alterations in fillet fatty acid profile and flesh quality in gilthead seabream (Sparus aurata) fed vegetable oils for a long term period. Recovery of fatty acid profiles by fish oil feeding. *Aquaculture*, *250*(1), 431-444.

Jaffry, S., Pickering, H., Ghulam, Y., Whitmarsh, D., and Wattage, P. (2004). Consumer choices for quality and sustainability labelled seafood products in the UK. Food Policy, 29(3), 215-228.

Jahncke, M., Hale, M. B., Gooch, J. A., and Hopkins, J. S. (1988). Comparison of Pond-Raised and Wild Red Drum (Sciaenopsocellatus) with Respect to Proximate Composition, Fatty Acid Profiles, and Sensory Evaluations. *Journal of Food Science*, *53*(1), 286-287.

Järup, L. (2003). Hazards of heavy metal contamination. *British medical bulletin*, *68*(1), 167-182.

Jehn, M., and Brewis, A. (2009). Paradoxical malnutrition in mother-child pairs: untangling the phenomenon of over- and under-nutrition in underdeveloped economies. Econ Hum Biol. 2009; 7:28-35.

Jensen, G. L., & Greenlees, K. J. (1997). Public health issues in aquaculture. *Revue scientifique et technique (International Office of Epizootics)*, *16*(2), 641-651.

Johnsen, P. B., Civille, G. V., & Vercelloti, J. R. (1987). A lexicon of pond-raised catfish flavor descriptors. *Journal of Sensory Studies*, *2*(2), 85-91.

Johnston, R. J., Wessells, C. R., Donath, H., and Asche, F. (2001). Measuring consumer preferences for ecolabeled seafood: an international comparison. Journal of Agricultural and resource Economics, 20-39.

Johnston, I. A., Li, X., Vieira, V. L., Nickell, D., Dingwall, A., Alderson, R., ... & Bickerdike, R. (2006). Muscle and flesh quality traits in wild and farmed Atlantic salmon. *Aquaculture*, *256*(1), 323-336.

Johnston, J. L., Fanzo, J. C., & Cogill, B. (2014). Understanding Sustainable Diets: A Descriptive Analysis of the Determinants and Processes That Influence Diets and Their Impact on Health, Food Security, and Environmental Sustainability. Advances in Nutrition, 5(4), 418–429.

Jones, B., Fuller, S., & Carton, A. G. (2013). Earthy-muddy tainting of cultured barramundi linked to geosmin in tropical northern Australia. *Aquaculture Environment Interactions*, *3*(2), 117-124.

Josephson, D. B., & Lindsay, R. C. (1986). Enzymic generation of volatile aroma compounds from fresh fish.

Kalantzi, I., Black, K. D., Pergantis, S. A., Shimmield, T. M., Papageorgiou, N., Sevastou, K., & Karakassis, I. (2013). Metals and other elements in tissues of wild fish from fish farms and comparison with farmed species in sites with oxic and anoxic sediments. *Food chemistry*, *141*(2), 680-694.

Kang, J. X. (2011). Omega-3: A link between global climate change and human health. Biotechnology advances, 29(4), 388-390.

Karapanagiotidis, I. T., Bell, M. V., Little, D. C., Yakupitiyage, A., & Rakshit, S. K. (2006). Polyunsaturated fatty acid content of wild and farmed tilapias in Thailand: effect of aquaculture practices and implications for human nutrition. *Journal of Agricultural and Food Chemistry*, *54*(12), 4304-4310.

Kawarazuka, N. (2010). The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: A literature review. The WorldFish Center Working Paper No. 2106. The WorldFish Center, Penang, Malaysia. 44 p.

Kearney, J. (2010). Food consumption trends and drivers. Philosophical Transactions of the Royal Society of London B: Biological Sciences, 365(1554), 2793-2807.

Kiessling, A., Espe, M., Ruohonen, K., & Mørkøre, T. (2004). Texture, gaping and colour of fresh and frozen Atlantic salmon flesh as affected by pre-slaughter iso-eugenol or CO 2 anaesthesia. *Aquaculture*, *236*(1), 645-657.

Kissinger, M. (2012). International trade related food miles–The case of Canada. Food Policy, 37(2), 171-178.

Klein, C. and Ferrari, R. (2012, October 19). "Conflicting sustainable seafood guides confuse consumers". The Conversation. Available at http://theconversation.com/conflicting-sustainableseafood-guides-confuse-consumers-9867

Kodavanti, P. R. S., Ward, T. R., Derr-Yellin, E. C., Mundy, W. R., Casey, A. C., Bush, B., & Tilson, H. A. (1998). Congener-specific distribution of PCBs in brain regions, blood, liver, and fate of adult rats following repeated exposure to Aroclor 1254. Toxicol Appl Pharmacol, 153(2), 199-210.

Korhonen, R.W., Lanier, T.C., and Giesbrecht, F. (1990). An evaluation of simple methods for following rigor development in fish. J Food Sci. 1990;55:346–9.

Kris-Etherton, P. M., Harris, W. S., and Appel, L. J. (2003). Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Arteriosclerosis, thrombosis, and vascular biology, 23(2), e20-e30.

Kumar, R. (2014) Research Methodology: A Step-by-Step Guide for Beginners, 4th edn. Sage, Los Angeles.

Lall, S. P. (1995). Macro and trace elements in fish and shellfish. Fish and fishery products: composition, nutritive properties and stability, 187-214.

Lang, T. (2009). Reshaping the food system for ecological public health. *Journal of Hunger & Environmental Nutrition*, *4*(3-4), 315-335.

Lawley, M. (2014). Sustainable seafood: A framework of current Stakeholder perspectives and approaches. Retrieved from: http://eprints.bournemouth.ac.uk/21346/3/Sustainable%2520seafood%2520A%2520framework%2520of%2520current%2520Stakeholder%2520perspectives%2520and%2520approaches.docx.pdf

Lee, J., Houser, R.F., Must, A., de Fuladolsa, P.P., and Bermudez, O.I. (2012). Socioeconomic disparities and the familial coexistence of child stunting and maternal overweight in Guatemala. Econ Hum Biol. 2012; 10:232-41.

Leek, S., Maddock, S., and Foxall, G. (2000). Situational determinants of fish consumption. British Food Journal, 102(1), 18–39. doi:10.1108/00070700010310614

Lees, R.S. (1988). The Impact of Dietary Fat on Human Health. MITSG 88-3, Massachusetts Institute of Technology Sea Grant, Massachusetts Institute of Technology, Cambridge, MA.

Leire, C. and Thidell, Å. (2005). Product-related environmental information to guide consumer purchases–a review and analysis of research on perceptions, understanding and use among Nordic consumers. Journal of Cleaner Production, 13(10): 1061-1070.

Leong, Y.H., Chiang, P.N., Jaafar, H.J., Gan, C.Y., and Majid, M.I.A. (2014). Contamination of food samples from Malaysia with polychlorinated dibenzo-p-dioxins and dibenzofurans and estimation of human intake. Food Addit Contam. 2014;31:711–718. doi: 10.1080/19440049.2014.880519.

Li, A.M.L (2016). Health Promotion of Sustainable Diets: Key for Obesity Epidemic and Environmental Sustainability. J Nutr Health Food Eng 4(2): 00126.

Listrat, A., Lebret, B., Louveau, I., Astruc, T., Bonnet, M., Lefaucheur, L., ... & Bugeon, J. (2016). How muscle structure and composition influence meat and flesh quality. *The Scientific World Journal*, *2016*.

Little, D.C., Bush, S.R., Belton, B., Thanh Phuong, N., Young, J.A. and Murray, F.J. (2012). Whitefish wars: Pangasius, politics and consumer confusion in Europe. Marine Policy, 36(3): 738-745.

Livingstone, M.B. and Black, A.E. (2003) Markers of the validity of reported energy intake. J Nutr 133, S895–S920

Lopparelli, R. M., Segato, S., Corato, A., Fasolato, L., & Andrighetto, I. (2004). Sensory evaluation of sea bass (Dicentrarchus labrax L.) fed two diets differing in fat content. *Veterinary research communications*, *28*(1), 225-227.

Love, R. M. (1975). Variability in Atlantic cod (Gadus morhua) from the Northeast Atlantic: a review of seasonal and environmental influences on various attributes of the flesh. *Journal of the Fisheries Board of Canada*, *32*(12), 2333-2342.

Love, R. M. (1997). Biochemical dynamics and the quality of fresh and frozen fish. In *Fish processing technology* (pp. 1-31). Springer US.

Lövkvist, S. (2014). An investigation of the lipid content and lipid composition in Atlantic salmon, pink salmon and striped catfish, obtained at the local retailers in Uppsala, Sweden.

Lowe, T.E., Ryder, J.M., Carragher, J.F., and Wells, R.M.G. (1993). Flesh quality of snapper, Pagrus auratus, affectedby capture stress. J Food Sci. 1993;58:771–3.

Loy, S.L., Marhazlina, M., Nor, A.Y., and Hamid, J.J. (2011). Development, validity and reproducibility of a food frequency questionnaire in pregnancy for the universiti sains Malaysia birth cohort study. Malays. J. Nutr. 2011;17:1–18.

Macdiarmid, J. I., Kyle, J., Horgan, G. W., Loe, J., Fyfe, C., Johnstone, A., & McNeill, G. (2012). Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet?. *The American journal of clinical nutrition*, *96*(3), 632-639.

Mahabir, S., Baer, D. J., Giffen, C., Subar, A., Campbell, W., Hartman, T. J., ... & Taylor, P. R. (2006). Calorie intake misreporting by diet record and food frequency questionnaire compared to doubly labeled water among postmenopausal women. European journal of clinical nutrition, 60(4), 561.

Martinsen, C., Lauby, B. B., Nevissi, A., & Brannon, E. (1992). The influence of crude oil and dispersant on the sensory characteristics of steelhead (Oncorhynchus mykiss) in marine waters. *Journal of Aquatic Food Product Technology*, *1*(1), 37-52.

Mazur, N., Aslin, H., and Byron, I. (2005). Community Perceptions of Aquaculture: Final Report.

McManus, A., Burns, S. K., Howat, P. A., Cooper, L., and Fielder, L. (2007). Factors influencing the consumption of seafood among young children in Perth: a qualitative study. BMC Public Health, 7, 119. doi:10.1186/1471-2458-7-119

McNutt, S., Zimmerman, T.P., and Hull, S.G. (2008). Development of food composition databases for food frequency questionnaires. J Food Compos Anal. 2008;21(1suppl):s20-s26.

Mina, K., Fritschi, L., Knuiman, M. (2007). A valid semiquantitative food frequency questionnaire to measure fish consumption. Eur J Clin Nutr. 2007;61:1023–31.

Ministry of Health Singapore (2011). Singapore Food Composition Database: Energy and Nutrient Composition of Food. Available from: focos.hpb.gov.sg/eservices/ENCF/

Ministry of Health Singapore (2014). My Healthy Plate. Available from: https://www.healthhub.sg/programmes/55/my-healthy-plate

Mirnalini Jr, K., Zalilah, M. S., Safiah, M. Y., Tahir, A., Siti, H. M., Siti, R. D., ... and Normah, H. (2008). Energy and Nutrient Intakes: Findings from the Malaysian Adult Nutrition Survey (MANS). Malaysian journal of nutrition, 14(1), 1-24.

Mohammad Arriff, M.R. and Mohammad Raduan, M.S. (2009) Perusahan pukat tunda di Semenanjung Malaysia, 1965- 2005: «Ditelan mati emak di luah mati bapak». Jurnal Jabatan Pengajian Asia Tenggara 14: 89-102.

Mohd, S.M., and Abdul Manan, M.J. (2012) Therapeutic potential of the haruan (Channa striatus): from food to medicinal uses Malays J Nutr, 18 (1) (2012), pp. 125–136

Mohd Taupek, M.N. (2003) Monitoring, measurement and assessment of fishing capacity - The Malaysian experience. FAO Fisheries Technical Paper 445. Food and Agriculture Organization of the United Nations (FAO), Rome. 127-142 p.

Montero, D., Robaina, L., Caballero, M. J., Ginés, R., & Izquierdo, M. S. (2005). Growth, feed utilization and flesh quality of European sea bass (Dicentrarchus labrax) fed diets containing vegetable oils: a time-course study on the effect of a re-feeding period with a 100% fish oil diet. *Aquaculture*, *248*(1), 121-134.

Muhamad, N.A. and Mohamad, J. (2012) Fatty Acids Composition of Selected Malaysian Fishes (Komposisi Asid Lemak Ikan Terpilih Malaysia). Sains Malaysiana 41(1)(2012): 81–94

Murphy, S., Ruel, M., and Carriquiry, A. (2012). Should Household Consumption and Expenditures Surveys (HCES) be used for nutritional assessment and planning? Food Nutr Bull 2012;33:S235–41.

Murray, J. and Burt, J.R. (2001). The Composition of Fish. Torry Advisory Note No. 38, Ministry of Technology. Torry Research Station, U.K., 14 pp.

Myrland, Ø., Trondsen, T., Johnston, R. S., and Lund, E. (2000). Determinants of seafood consumption in Norway: lifestyle, revealed preferences, and barriers to consumption. Food Quality and Preference, 11(3), 169–188. doi:http://dx.doi.org/10.1016/S0950-3293(99)00034-8

Nair, S. (2010). Moving forward: Its poverty agenda challenges, dilemma and options for Malaysia. Proceedings of the Chronic Poverty Research Centre 2010 Conference, September 8-10, 2010, United Kingdom.

Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C., Clay, J., ... & Troell, M. (2000). Effect of aquaculture on world fish supplies. Nature, 405(6790), 1017-1024.

NCFFN (2005). National Coordinating Committee on Food and Nutrition: Recommended Nutrient Intakes for Malaysia. Ministry of Health Malaysia, Kuala Lumpur.

Needham, S., and Funge-Smith, S. J. (2014). The consumption of fish and fish products in the Asia-Pacific region based on household surveys. FAO Regional Office for Asia and the Pacific. Bangkok, Thailand: RAP Publication.

Nettleton, J. A., & Exler, J. (1992). Nutrients in wild and farmed fish and shellfish. *Journal of Food Science*, *57*(2), 257-260.

New Zealand Institute of Chemistry (2008). Fish Processing. http://www.nzic.org.nz/ChemProcesses/animal/5D.pdf

Newton, N. (2010). The use of semi-structured interviews in qualitative research: strengths and weaknesses. *Exploring qualitative methods*, *1*(1), 1-11.

Ng, T.K.W. (2006). Omega-3 fatty acids: Potential sources in the Malaysian diet with the goal towards achiving recommended nutrient intakes. Malaysian Journal of Nutrition 12: 181-188.

Ngo, J., Gurinovic, M., Frost-Andersen, L., & Serra-Majem, L. (2009). How dietary intake methodology is adapted for use in European immigrant population groups–a review. British Journal of Nutrition, 101(S2), S86-S94.

Nguyen, T. T., and Olsen, S. O. (2012). Attitude toward and Consumption of Fish in Vietnam. Journal of Food Products Marketing, 18(2), 79–95. doi:10.1080/10454446.2012.653778

Nichols, P. D., Glencross, B., Petrie, J. R., and Singh, S. P. (2014). Readily Available Sources of Long-Chain Omega-3 Oils: Is Farmed Australian Seafood a Better Source of the Good Oil than Wild-Caught Seafood? Nutrients, 6(3), 1063–1079. http://doi.org/10.3390/nu6031063

Noordiana, N., Fatimah, A. B. and Farhana, Y. C. B. (2011). Formaldehyde content and quality characteristics of selected fish and seafood from wet markets. International Food Research Journal 18(1): 125-136.

Norimah Jr, A. K., Safiah, M., Jamal, K., Haslinda, S., Zuhaida, H., Rohida, S., ... and Zalilah, M. S. (2008). Food Consumption Patterns: Findings from the Malaysian Adult Nutrition Survey (MANS). Malaysian Journal of Nutrition, 14(1), 25-39.

Nøstbakken, O. J., Hove, H. T., Duinker, A., Lundebye, A. K., Berntssen, M. H., Hannisdal, R., ... & Julshamn, K. (2015). Contaminant levels in Norwegian farmed Atlantic salmon (Salmo salar) in the 13-year period from 1999 to 2011. *Environment international*, *74*, 274-280.

Nunnally, J. C. (1978). Psychometric theory (2nd ed.). New York, NY: McGraw-Hill.

Oddo, V. M., Rah, J. H., Semba, R. D., Sun, K., Akhter, N., Sari, M., ... & Kraemer, K. (2012). Predictors of maternal and child double burden of malnutrition in rural Indonesia and Bangladesh. The American journal of clinical nutrition, 95(4), 951-958.

Oken, E., Choi, A. L., Karagas, M. R., Mariën, K., Rheinberger, C. M., Schoeny, R., ... and Korrick, S. (2012). Which fish should I eat? Perspectives influencing fish consumption choices. Environmental health perspectives, 120(6), 790.

Olsen, S. O. (2001). Consumer involvement in seafood as family meals in Norway: an application of the expectancy-value approach. Appetite, 36(2), 173–186. doi:http://dx.doi.org/10.1006/appe.2001.0393

Olsen, S.O. (2003). Understanding the relationship between age and seafood consumption: the mediating role of attitude, health involvement and convenience. Food Quality and Preference, Vol. 14, pp. 199 – 209.

Olsen, S.O. (2004). Antecedents of Seafood Consumption Behaviour: An Overview. Journal of Aquatic Food Product Technology, 13(3), 79-91.

Olsen, R. E., Henderson, R. J., Sountama, J., Hemre, G. I., Ringø, E., Melle, W., & Tocher, D. R. (2004). Atlantic salmon, Salmo salar, utilizes wax ester-rich oil from Calanus finmarchicus effectively. Aquaculture, 240(1), 433-449.

Olsen, R. E., Suontama, J., Langmyhr, E., Mundheim, H., Ringø, E., Melle, W., ... and HEMRE, G. I. (2006). The replacement of fish meal with Antarctic krill, Euphausia superba in diets for Atlantic salmon, Salmo salar. Aquaculture Nutrition, 12(4), 280-290.

Olsson, G. B., Olsen, R. L., Carlehög, M., & Ofstad, R. (2003). Seasonal variations in chemical and sensory characteristics of farmed and wild Atlantic halibut (Hippoglossus hippoglossus). *Aquaculture*, *217*(1), 191-205.

Orban, E., Sinesio, F., & Paoletti, F. (1997). The functional properties of the proteins, texture and the sensory characteristics of frozen sea bream fillets (Sparus aurata) from different farming systems. *LWT-Food Science and Technology*, *30*(2), 214-217.

Osman, F., Jaswir, I., Khaza'ai, H., Hashim, R. (2007). Fatty acid profiles of fin fish in Lankgkawi Island, Malaysia. J Oleo Sci. 2007;56:107–113.

Osman, H., Suriah, A.R. and Law, E.C. (2001). Fatty acid composition and cholesterol content of selected marine fish in Malaysian waters. Food Chemistry 73: 55-60.

Ostenfeld, T., Thomsen, S., Ingóldfóttir, S., Ronshold, B., & McLean, E. (1995). Evaluation of the effect of live haulage on metabolites and fillet texture of rainbow trout (Oncorhynchus mykiss). *Water Science and Technology*, *31*(10), 233-237.

Othman, A. and F. Kari (2008). Enhancing co-operatives movement to achieve Malaysia's development goals. Proceedings of the ICA Research Conference, October 16-18, 2008, Trento, Italy.

Padula, D. J., Daughtry, B. J., & Nowak, B. F. (2008). Dioxins, PCBs, metals, metalloids, pesticides and antimicrobial residues in wild and farmed Australian southern bluefin tuna (Thunnus maccoyii). *Chemosphere*, *72*(1), 34-44.

Pathansali, D. (1961) A preliminary report on the Rastrelliger fishery in Malaya. Proceedings of the Indo-Pacific Fisheries Council 2, Asia Pacific Fishery Commission. 37-45 p. Available at: http://www.apfic.org/Archive/ techpapers/1961/06.pdf

Pelletier, D. L. (1997). Advanced training in food and nutrition: disciplinary, interdisciplinary, and problem-oriented approaches. FOOD AND NUTRITION BULLETIN-UNITED NATIONS UNIVERSITY-, 18, 134-145.

Pelletier, N., Audsley, E., Brodt, S., Garnett, T., Henriksson, P., Kendall, A., Kramer, K.-J., Murphy, D., Nemecek, T. and Troell, M. (2011). Energy intensity of agriculture and food systems. Annual Review of Environment and Resources.

Percival, S., Drabsch, P., & Glencross, B. (2008). Determining factors affecting muddy-flavour taint in farmed barramundi, Lates calcarifer. *Aquaculture*, *284*(1), 136-143.

Periago, M. J., Ayala, M. D., López-Albors, O., Abdel, I., Martinez, C., García-Alcázar, A., ... & Gil, F. (2005). Muscle cellularity and flesh quality of wild and farmed sea bass, Dicentrarchus labrax L. *Aquaculture*, *249*(1), 175-188.

Peter, J.P. (1979) Reliability: A Review of Psychometric Basics and Recent Marketing Practices, Journal of Marketing Research, 16(1), 6-17

Phillips, M.J., Boyd, C. & Edwards, P. (2001). Systems approach to aquaculture management. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 239-247. NACA, Bangkok and FAO, Rome.

Pieniak, Z., Verbeke, W., Perez-Cueto, F., Brunsø, K., & De Henauw, S. (2008). Fish consumption and its motives in households with versus without self-reported medical history of CVD: A consumer survey from five European countries. BMC Public Health, 8(1), 306.

Pimentel, D., and Pimentel, M. (2003). Sustainability of meat-based and plant-based diets and the environment. The American journal of clinical nutrition, 78(3), 660S-663S.

Pimolrat, P., Whangchai, N., Chitmanat, C., Itayama, T., & Lebel, L. (2015). Off-flavor Characterization in high nutrient load Tilapia ponds in northern Thailand.

Pingali, P. (2007). Westernization of Asian diets and the transformation of food systems: Implications for research and policy. Food Policy 32, 281-298.

Polymeros, K., Kaimakoudi, E., Schinaraki, M., and Batzios, C. (2015). Analysing consumers' perceived differences in wild and farmed fish. British Food Journal, 117(3), 1007–1016. doi:10.1108/BFJ-12-2013-0362

Pong, L.Y. (1992) Multispecies fish resources and multispecies fisheries in the coastal waters of Peninsular Malaysia, with special reference to the west coast. FAO Fisheries Report No. 463, Food and Agriculture Organization of the United Nations (FAO), Rome. 184-209 p.

Popkin, B.M. (1994). The nutrition transition in low income countries: an emerging crisis. Nutr Rev. 1994; 52:285-98.

Popkin, B. M., Adair, L. S., and Ng, S. W. (2012). NOW AND THEN: The Global Nutrition Transition: The Pandemic of Obesity in Developing Countries. Nutrition Reviews, 70(1), 3–21. http://doi.org/10.1111/j.1753-4887.2011.00456.x

Poslusna, K., Ruprich, J., de Vries, J.H., Jakubikova, M., and van't Veer, P. (2009). Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. Br J Nutr. 2009 Jul;101 Suppl 2:S73-85. doi: 10.1017/S0007114509990602.

Povey, R., Wellens, B. and Conner, M. (2001). Attitudes towards following meat, vegetarian and vegan diets: An examination of the role of ambivalence. Appetite, Vol.37, pp. 15–26.

Puwastien, P., Burlingame, B., Raroengwichit, M., & Sungpuag, P. (2000). ASEAN food composition tables. Institute of Nutrition, Mahidol University (INMU), ASEANFOODS Coordinator and INFOODS Regional Database Centre, Bangkok, Thailand.

Radimer, K., Bindewald, B., Hughes, J., Ervin, B., Swanson, C., and Picciano, M.F. (2004). Dietary supplement use by US adults: data from the National Health and Nutrition Examination Survey, 1999–2000. Am J Epidemiol. 2004;160(4):339–349. doi: 10.1093/aje/kwh207.

Raduan, M., Sharir, M. and Aziz, Z. (2007) Masalah nelayan tradisional di Semenanjung Malaysia: Penyelesaian Tanpa Kesudahan. Jurnal Jabatan Pengajian Asia Tenggara 12: 247-258

Rasmussen, R. S. (2001). Quality of farmed salmonids with emphasis on proximate composition, yield and sensory characteristics. *Aquaculture Research*, *32*(10), 767-786.

Reddy, L., Odhav, B., and Bhoda, K.D. (2003). Natural products for cancer prevention. Pharmacol. Therapeut. 99, 1–13.

Redkar, S.B. and Bose, S. (2004). Modelling purchasingdecisions of seafood products: a case study ofMumbai, India. Int. J. Consum. Stud., 28: 75-82.

Ritchie, J. and Lewis, J. (2003). Qualitative research practice : a guide for social science students and researchers. London: SAGE.

Robertson, R. F., Hammond, A., Jauncey, K., Beveridge, M. C. M., & Lawton, L. A. (2006). An investigation into the occurrence of geosmin responsible for earthy–musty taints in UK farmed rainbow trout, Onchorhynchus mykiss. *Aquaculture*, *259*(1), 153-163.

Robin, J., Cravedi, J. P., Hillenweck, A., Deshayes, C., & Vallod, D. (2006). Off flavor characterization and origin in French trout farming. *Aquaculture*, *260*(1), 128-138.

Roheim, C. and Sutinen, J.G. (2006). Trade and marketplace measures to promote sustainable fishing practices. International Centre for Trade and Sustainable Development (ICTSD).

Rossato, S. L., and Fuchs, S. C. (2014). Handling random errors and biases in methods used for short-term dietary assessment. Revista de Saúde Pública, 48(5), 845–850. http://doi.org/10.1590/S0034-8910.2014048005154

Roth, B., Slinde, E., & Arildsen, J. (2006). Pre or post mortem muscle activity in Atlantic salmon (Salmo salar). The effect on rigor mortis and the physical properties of flesh. *Aquaculture*, *257*(1), 504-510.

Royne, M.B., Fox, A.K., Deitz, G.D., and Gibson, T. (2014) The effects of health consciousness and familiarity with DTCA on perceptions of dietary supplements. Journal of Consumer Affairs, 48 (3) (2014), pp. 515–534

Ruiz-Lopez, N., Sayanova, O., Napier, J.A., and Haslam, R.P. (2012). Metabolic engineering of the omega-3 long chain polyunsaturated fatty acid biosynthetic pathway into transgenic plants. J Exp Bot. 2012;63:2397–2410. doi: 10.1093/jxb/err454.

Ruiz-Lopez, N., Haslam, R. P., Napier, J. A., and Sayanova, O. (2014). Successful high level accumulation of fish oil omega-3 long-chain polyunsaturated fatty acids in a transgenic oilseed crop. The Plant Journal, 77(2), 198-208.

Sáez-Almendros, S., Obrador, B., Bach-Faig, A., and Serra-Majem, L. (2013). Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. Environmental Health, 12(1), 118.

Sapkota, A., Sapkota, A. R., Kucharski, M., Burke, J., McKenzie, S., Walker, P., & Lawrence, R. (2008). Aquaculture practices and potential human health risks: current knowledge and future priorities. *Environment international*, *34*(8), 1215-1226.

Sato, K., Yoshinaka, R., Sato, M., Shimizu, Y. (1986) Collagen content in the muscle of fishes in association with their swimming movement and meat texture. Bulletin of the Japanese Society of Scientific Fisheries 52, 1595–1600.

Scarborough, P., Allender, S., Clarke, D., Wickramasinghe, K. and Rayner, M. (2012). Modelling the health impact of environmentally sustainable dietary scenarios in the UK. European Journal of Clinical Nutrition, 66(6): 710-715.

Scarborough, P., Appleby, P.N., Mizdrak, A., Briggs, A.D., Travis, R.C., Bradbury, K.E. and Key, T.J., (2014). Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. Climatic change, 125(2), pp.179-192.

Schlag, A.K. and Ystgaard, K. (2013). Europeans and aquaculture: perceived differences between wild and farmed fish. British Food Journal, Vol. 115 Iss: 2, pp.209 – 222.

Schofield, W.N. (1985) Predicting basal metabolic rate, new standards and review of previous work. Hum Nutr Clin Nutr 39, Suppl. 1, 5–41.

Scholderer, J. and Trondsen, T. (2008). The dynamics of consumer behaviour: On habit, discontent, and other fish to fry. Appetite, 51(3): 576-591.

Selamat, R., Ahmad, H., Chong, Z. L., Zainuddin, A. A., Mohd Shariff, Z., Bakar, M. A., and Azdie, W. (2015). Household food insecurity in Malaysia: findings from Malaysian Adults Nutrition Survey. The Medical Journal of Malaysia, 70(S1), 11.

Sérot, T., Gandemer, G., & Demaimay, M. (1998). Lipid and fatty acid compositions of muscle from farmed and wild adult turbot. *Aquaculture International*, *6*(5), 331-343.

Serrano, P. H. (2005). *Responsible use of antibiotics in aquaculture* (No. 469). Food & Agriculture Org..

Shahar, S., Yusoff, N. A. M., Safii, N. S., Ghazali, R., & Ahmad, R. (2009). Atlas Makanan: Saiz Pertukaran dan Porsi Edisi Kedua. Kuala Lumpur: MDC Publisher Sdn Bhd.

Sharif, R., Ghazali, A.R., Rajab, N.F., Haron, H., and Osman, F. (2008). Toxicological evaluation of some Malaysian locally processed raw food products. Food and Chemical Toxicology; 46(1):368-74.

Shawyer, M. and Medina Pizzali, A.F. (2003). The use of ice on small fishing vessels. FAO Fisheries Technical Paper. No. 436. Rome, FAO. 108 pp

Sheila, M.I. (2007). Dietary (n-3) Fatty Acids and Brain Development. American Society for Nutrition. J. Nutr. 137: 855–859.

Shepherd, R. and Raats, M.M. (1996). Attitude and beliefs in food habits. In H. L. Meiselman, and H. J. H. MacFie (Eds.), Food choice, acceptance and consumption (pp. 346–364). London, UK: Blackie Academic and Professional.

Sigholt, T., Erikson, U., Rustad, T., Johansen, S., Nordtvedt, T. S., & Seland, A. (1997). Handling Stress and Storage Temperature Affect Meat Quality of Farmed-raised Atlantic Salmon (Salmo Salar). *Journal of Food Science*, *62*(4), 898-905.

Siti Aminah, A., Zailina. H., Fatimah, A.B. (2013). Health risk Assessment of adults consuming commercial fish contaminated with formaldehyde. Food and Public Health, 3(1), 52-58.

Siwar, C. and M.Y. Kasim (1997). Urban development and urban poverty in Malaysia. Int. J. Soc. Econ., 24: 1524-1535.

Siwar, C., Ahmed, F., Bashawir, A., and Mia, M. S. (2016). Urbanization and Urban Poverty in Malaysia: Consequences and Vulnerability. Journal of Applied Sciences, 16, 154-160.

Skjervold, P. O., Fjæra, S. O., Østby, P. B., & Einen, O. (2001). Live-chilling and crowding stress before slaughter of Atlantic salmon (Salmo salar). *Aquaculture*, *192*(2), 265-280.

Smith, J. L., Boyer, G. L., & Zimba, P. V. (2008). A review of cyanobacterial odorous and bioactive metabolites: impacts and management alternatives in aquaculture. *Aquaculture*, *280*(1), 5-20.

Smith, A.D., Brown, C.J., Bulman, C.M., Fulton, E.A., Johnson, P., Kaplan, I.C., Lozano-Montes, H., Mackinson, S., Marzloff, M., Shannon, L.J., Shin, Y.-J. and Tam, J. (2011). Impacts of fishing low–trophic level species on marine ecosystems. Science, 333(6046): 1147-1150.

Smith, P. (2014). Climate change 2014: Mitigation of climate change. Contribution of working Group III to the fifth assessment report of the Intergovernmental Panel on Climate Change; Edenhofer, O., Eds.;Cambridge University Press: Cambridge and New York, 2014; Chapter 11, pp 1– 179.

Soto, D., Aguilar-Manjarrez, J., Brugère, C., Angel, D., Bailey, C., Black, K., ... & Freeman, S. (2008). Applying an ecosystem-based approach to aquaculture: principles, scales and some management measures. *Building an ecosystem approach to aquaculture*, *14*.

Spinks, A., and Bose, S. (2002). Factors affecting households' seafood purchasing decisions in Auckland, New Zealand: an empirical analysis. International Journal of Consumer Studies, 26(1), 62–70. doi:10.1046/j.1470-6431.2002.00219.x

Sprague, M., Walton, J., Campbell, P. J., Strachan, F., Dick, J. R., and Bell, J. G. (2015). Replacement of fish oil with a DHA-rich algal meal derived from Schizochytrium sp. on the fatty acid and persistent organic pollutant levels in diets and flesh of Atlantic salmon (Salmo salar, L.) post-smolts. Food chemistry, 185, 413-421.

Sprague, M., Dick, J. R., & Tocher, D. R. (2016). Impact of sustainable feeds on omega-3 long-chain fatty acid levels in farmed Atlantic salmon, 2006–2015. *Scientific reports*, *6*, 21892.

Standal, D. and Utne, I.B. (2011). The hard choices of sustainability. Marine Policy, 35(4): 519-527.

Staniford, D. (2002). A big fish in a small pond: The global environmental and public health threat of sea cage fish farming. Paper presented at Sustainability of the Salmon Industry in Chile and the World workshop organized by the Terram Foundation and Universidad de los Lagos in Puerto Monte, Chile. 5–6 June.

Stobberup, K. (2011) Review of data collection systems in BOBLME countries. Bay of Bengal Large Marine Ecosystem Project. 88 p.

Streit, B. (1998). Bioaccumulation of contaminants in fish. In *Fish Ecotoxicology* (pp. 353-387). Birkhäuser Basel.

Strobel, C., Jahreis, G., & Kuhnt, K. (2012). Survey of n-3 and n-6 polyunsaturated fatty acids in fish and fish products. *Lipids in health and disease*, *11*(1), 144.

Stroud, G. D. (1969). *Rigor in fish: The effect on quality*. Torry Research Station.

Subar, A. (2004). Developing dietary assessment tools. J Am Diet Assoc. 2004;104(5):769-770

Subar, A. F., Kipnis, V., Troiano, R. P., Midthune, D., Schoeller, D. A., Bingham, S., ... & Sunshine, J. (2003). Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: the OPEN study. American journal of epidemiology, 158(1), 1-13.

Suyama, M., Hirano, T., Yamazake S. (1985). Quality of wild and cultured ayu. VI. Odor of ayu and its volatile components. Bulletin of the Japanese Society of Scientific Fisheries, *51*(2), 287-294.

Sveinsdóttir, K., Martinsdóttir, E., Green-Petersen, D., Hyldig, G., Schelvis, R., & Delahunty, C. (2009). Sensory characteristics of different cod products related to consumer preferences and attitudes. *Food Quality and Preference*, *20*(2), 120-132.

Svensson, B.G., Akesson, B., Nilsson, A., and Skerfving, S. (1993). Fatty acid composition of serum phosphatidylcholine in healthy subjects consuming varying amounts of fish. Eur J Clin Nutr 47, 132–140.

Swartz, W., Sala, E., Tracey, S., Watson, R., and Pauly, D. (2010). The spatial expansion and ecological footprint of fisheries (1950 to present). PloS one, 5(12), e15143.

Tachibana, K., Tsuchimoto, M., Misima, T., Ogura, M., Matsukiyo, K., & Yasuda, M. (1988). The effect of swimming exercise on flesh texture of cultured red sea-bream [Pagrus major]. *Bulletin of the Japanese Society of Scientific Fisheries (Japan)*.

Tan, S.C., Ong, K.J., and Raman, A. (2012, March 24). CAP: Formalin may have been used to preserve fish. The Star Newspaper. Retrieved from: http://www.thestar.com.my/news/nation/2012/03/24/cap-formalin-may-have-been-used-to-preserve-fish/#AdWBdLIKoiIq73gj.99

Tan, Y.K. (2003) Sport fishing to help land tourists. New Straits Times, edition of May 28, 2003.

Tan, A. K. G., Yen, S. T., and Hasan, A. R. (2015). At-Home Consumption of Fish Products in Malaysia: An Analysis of Household Expenditure Survey Data. Marine Resource Economics, 30(4), 417–433.

Tan, A., Guan, K., Lee, H., and Heng, S. (2005). Determinants Of Malaysian Household Expenditures On Freshfish, Shellfish, And Processed Fish.

Tang, X., Bai, Y., Duong, A., Smith, M.T., Li, L. and Zhang, L. (2009) Formaldehyde in China: production, consumption, exposure levels, and health effects. Environment international, 35, 1210−124.

Tanumihardjo, S.A., Anderson, C., Kaufer-Horwitz, M., Bode, L., Emenaker, N.J., Haqq, A.M., Satia, J.A., Silver, H.J. and Stadler, D.D., (2007). Poverty, obesity, and malnutrition: an international perspective recognizing the paradox. Journal of the American Dietetic Association, 107(11), pp.1966-1972.

Tavakol, M., and Dennick, R. (2011). Making sense of Cronbach's alpha. International journal of medical education, 2, 53.

Tee, E.S., Mohd Ismail, N., Mohd Nasir, A. and Khatijah, I. (1997). Nutrient Composition of Malaysian Foods(4th ed.), Malaysian Food Composition Database Programme.

Teh, L. and Teh, L. (2014) Reconstructing the Marine Fisheries Catch of Peninsular Malaysia, Sarawak and Sabah, 1950-2010. Fisheries Centre, The University of British Columbia

Tey, Y. S., Shamsudin, M. N., Mohamed, Z. A., Abdullah, A. M., and Radam, A. (2008). FOOD CONSUMPTION BEHAVIOR OF THE MALAYS IN MALAYSIA. IIUM Journal of Economics and Management, 16(2), 209–219.

Thilsted, S. H., Thorne-Lyman, A., Webb, P., Bogard, J. R., Subasinghe, R., Phillips, M. J., & Allison, E. H. (2016). Sustaining healthy diets: The role of capture fisheries and aquaculture for improving nutrition in the post-2015 era. *Food Policy*, *61*, 126-131.

Thompson, F.E. and Subar, A.F. (2013). Dietary assessment methodology. In Coulston AM, Boushey CJ, Ferruzzi MG, eds. Nutrition in the Prevention and Treatment of Disease.3rd ed. Amsterdam, Boston: Elsevier;2013:5-44.

Tilman, D., & Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature*, *515*(7528), 518-522.

Tobi, H. (2014). Measurement in interdisciplinary research: The contributions of widely-defined measurement and portfolio representations. Measurement, 48, 228-231.

Tobi, H., & Kampen, J. K. (2017). Research design: the methodology for interdisciplinary research framework. Quality & quantity, 52(3), 1209-1225.

Tocher, D. R. (2010). Fatty acid requirements in ontogeny of marine and freshwater fish. *Aquaculture Research*, *41*(5), 717-732.

Tooze, J.A., Krebs-Smith, S.M., Troiano, R.P., Subar, A.F. (2012). The accuracy of the Goldberg method for classifying misreporters of energy intake on a food frequency questionnaire and 24-h recalls: comparison with doubly labeled water. Eur J Clin Nutr. 2012, 66: 569-576. 10.1038/ejcn.2011.198.

Totland, G. K., Kryvi, H., Jødestøl, K. A., Christiansen, E. N., Tangerås, A., & Slinde, E. (1987). Growth and composition of the swimming muscle of adult Atlantic salmon (Salmo salar L.) during long-term sustained swimming. *Aquaculture*, *66*(3-4), 299-313.

Trondsen, T., Scholderer, J., Lund, E., and Eggen, A. E. (2003). Perceived barriers to consumption of fish among Norwegian women. Appetite, 41(3), 301–314. doi:http://dx.doi.org/10.1016/S0195-6663(03)00108-9

Tunhun, D., Kanont, S., Chaiyawat, M., and Raksakulthai, N. (1996). Detection of illegal addition of formaldehyde to fresh fish. ASEAN Food J. 11 : 74-77.

Uauy, R. and Kain, J. (2002). The epidemiological transition: need to incorporate obesity prevention into nutrition programmes. Public Health Nutr. 2002;5:223–229.

Uchida, H., Roheim, C. A., Wakamatsu, H., and Anderson, C. M. (2014). Do Japanese consumers care about sustainable fisheries? Evidence from an auction of ecolabelled seafood. Australian Journal of Agricultural and Resource Economics, 58(2), 263–280. doi:10.1111/1467-8489.12036

UN (2017). World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP/248.

USDA (2015). United States Department of Agriculture and Department of Health and Human Services: Scientific Report of the 2015 Dietary Guidelines Advisory Committee. Available at: http://health.gov/dietaryguidelines/2015-scientific-report/pdfs/scientific-report-of-the-2015-dietary-guidelines-advisory-committee.pdf

Usydus, Z., Szlinder-Richert, J., Adamczyk, M., & Szatkowska, U. (2011). Marine and farmed fish in the Polish market: Comparison of the nutritional value. *Food Chemistry*, *126*(1), 78-84.

Valin, H. (2014). The future of food demand: Understanding differences in global economic models Agr Econ, 45, 51– 67.

van Dooren, C., Marinussen, M., Blonk, H., Aiking, H., and Vellinga, P. (2014). Exploring dietary guidelines based on ecological and nutritional values: A comparison of six dietary patterns. Food Policy, 44, 36-46.

Van Houtan, K. S., McClenachan, L., and Kittinger, J. N. (2013). Seafood menus reflect long‐term ocean changes. Frontiers in Ecology and the Environment, 11(6), 289-290.

Vandevijvere, S., Chow, C. C., Hall, K. D., Umali, E., and Swinburn, B. A. (2015). Increased food energy supply as a major driver of the obesity epidemic: a global analysis. Bulletin of the World Health Organization, 93(7), 446-456.

Vanham, D., Mekonnen, M.M. and Hoekstra, A.Y. 2013. The water footprint of the EU for different diets. Ecological indicators, 32: 1-8.

Vanhonacker, F., Altintzoglou, T., Luten, J., and Verbeke, W. (2011). Does fish origin matter to European consumers?: Insights from a consumer survey in Belgium, Norway and Spain. British Food Journal, Vol. 113 Iss: 4, pp.535 – 549.

Vanhonacker, F., Pieniak, Z., and Verbeke, W. (2013). European consumer image of farmed fish, wild fish, seabass and seabream. Aquaculture International, 21(5), 1017–1033. doi:10.1007/s10499-012-9609-2

Vanhonacker, F., Van Loo, E. J., Gellynck, X., and Verbeke, W. (2013). Flemish consumer attitudes towards more sustainable food choices. Appetite, 62, 7–16. doi:http://dx.doi.org/10.1016/j.appet.2012.11.003

Venugopal, V. (Ed.). (2005). *Seafood processing: adding value through quick freezing, retortable packaging and cook-chilling*. CRC press.

Verbeke, W. and Vackier, I. (2005). Individual determinants of fish consumption: application of the theory of planned behaviour, Appetite, Vol. 44, pp. 67–82.

Verbeke, W., Sioen, I., Pieniak, Z., Van Camp, J., and De Henauw, S. (2005). Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. Public Health Nutr. 2005;8:422-429

Verbeke, W., Vanhonacker, F., Sioen, I., Camp, J.V. and De Henauw, S. (2007). Perceived importance of sustainability and ethics related to fish: a consumer behavior perspective. Ambio, Vol. 36(7) , 580–585.

Verbeke, W. (2005). Agriculture and the food industry in the information age. European Review of Agricultural Economics, 32(3): 347-368.

Verbeke, W., Sioen, I., Brunsø, K., De Henauw, S., and Van Camp, J. (2007). Consumer perception versus scientific evidence of farmed and wild fish: exploratory insights from Belgium. Aquaculture International, 15(2), 121–136. doi:10.1007/s10499-007-9072-7

Verbeke, W., Sioen, I., Pieniak, Z., Van Camp, J., and De Henauw, S. (2007). Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. Public Health Nutrition, 8(4), 422–429. doi:10.1079/PHN2004697

Vigani, M., Parisi, C., Rodríguez-Cerezo, E., Barbosa, M. J., Sijtsma, L., Ploeg, M., and Enzing, C. (2015). Food and feed products from micro-algae: Market opportunities and challenges for the EU. Trends in Food Science and Technology, 42(1), 81-92.

Wan Rosli, W.I., Rohana, A. J., Gan, S.H., Noor Fadzlina, H., Rosliza, H., Helmy, H., Mohd Nazri, S., Mohd Ismail, I., Shaiful Bahri, I., Wan Mohamad, W.B. and Kamarul Imran, M. (2012). Fat content and EPA and DHA levels of selected marine, freshwater fish and shellfish species from the east coast of Peninsular Malaysia. International Food Research Journal 19 (3): 815-821

Wang, F., Zhang, J., Mu, W., Fu, Z. and Zhang, X. (2009). Consumers' perception toward quality and safety of fishery products, Beijing, China. Food Control, 20(10): 918–922.

Wang, Y., Lehane, C., Ghebremeskel, K., and Crawford, M. A. (2010). Modern organic and broiler chickens sold for human consumption provide more energy from fat than protein. Public health nutrition, 13(3), 400-408.

WHO (2000). World Health Organization International Obesity Task Force. The Asian-Pacific perspective: redefining obesity and its treatment, WHO Western Pacific Region, Geneva, Switzerland

WHO (2003). Diet, Nutrition and the Prevention of Chronic Diseases. Report of a Joint WHO/ FAO Expert Consultation Technical Report Series 916.

WHO (2006). Toxicological evaluation of certain veterinary drug residues in food (Vol. 57). World Health Organization.

WHO (2008) Interim Summary of Conclusions and Dietary Recommendations on Total Fat and Fatty Acids From the Joint FAO/WHO Expert Consultation on Fats and Fatty Acids in Human Nutrition. Geneva: 2008 Nov 10-14

WHO (2012). Malaysia health system review. Available from: http://www.wpro.who.int/asia_pacific_observatory/hits/series/Malaysia_Health_Systems_Review2013.pdf

WHO (2016). Fact sheet: Obesity and overweight. Available from: http://www.who.int/mediacentre/factsheets/fs311/en/

WHO (2017) Global Database on Body Mass Index. An interactive surveillance tool for monitoring nutrition transition. [accessed on 2017 Feb 22]. Available from: http://apps.who.int/bmi

WHO Global Health Observatory (GHO) data (2014). [accessed on 2017 Feb 22]. Available from: http://www.who.int/gho/ncd/risk_factors/overweight/en/

WHO/FAO Joint Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases (2002). Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. WHO technical report series ; 916.

Willet, W. ed (1998). Nutritional Epidemiology. 2nd ed. New York, Oxford: Oxford University Press; 1998:74-94.

Wong, C. Y., Zalilah, M. S., Chua, E. Y., Norhasmah, S., Chin, Y. S., and Nur'Asyura, A. S. (2015). Double-burden of malnutrition among the indigenous peoples (Orang Asli) of Peninsular Malaysia. BMC public health, 15(1), 680.

Wrieden, W., Peace, H., Armstrong, J., Barton, K,, (2003). A short review of dietary assessment methods used in National and Scottish Research Studies. Briefing Paper Prepared for: Working Group on Monitoring Scottish Dietary Targets Workshop

Xu, P., Zeng, Y., Fong, Q., Lone, T., and Liu, Y. (2012). Chinese consumers' willingness to pay for green- and eco-labeled seafood. Food Control, 28(1), 74–82. doi:http://dx.doi.org/10.1016/j.foodcont.2012.04.008

Yildiz, M. (2008). Mineral composition in fillets of sea bass (Dicentrarchus labrax) and sea bream (Sparus aurata): a comparison of cultured and wild fish. *Journal of Applied Ichthyology*, *24*(5), 589-594.

Yipel, M., Erdinç, T. Ü. R. K., Tekeli, I. O., & Halis, O. Ğ. U. Z. (2016). Heavy Metal Levels in Farmed and Wild Fishes of Aegean Sea and Assessment of Potential Risks to Human Health. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, *22*(6), 889-894.

Youn, S. J., Taylor, W. W., Lynch, A. J., Cowx, I. G., Beard, T. D., Bartley, D., and Wu, F. (2014). Inland capture fishery contributions to global food security and threats to their future. Global Food Security, 3(3), 142-148.

Yusoff, A. (2015). Status of resource management and aquaculture in Malaysia. In Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia: Challenges in Responsible Production of Aquatic Species: Proceedings of the International Workshop on Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia 2014 (RESA) (pp. 53-65). Aquaculture Department, Southeast Asian Fisheries Development Center.

Yusoff, R.B. (2013). Urban development challenges in the Malaysian context. Proceedings of the Conference on Regional Urban Policy Exchange, September 19, 2013, Beijing, China.

Zakariah, Z.M. (2008). The status of marine recreational fishing in Malaysia. pp. 36-39 In Aas O (ed.), Global challenges in recreational fisheries. Blackwell Publishing Ltd., Singapore.

Zhang, X. G. (2002, April). Consumption trends and habits for aquatic products in China. In Paper from AquaSur international conference (pp. 18-19).

Zhou, S., Smith, A. D., Punt, A. E., Richardson, A. J., Gibbs, M., Fulton, E. A., ... & Sainsbury, K. (2010). Ecosystem-based fisheries management requires a change to the selective fishing philosophy. *Proceedings of the National Academy of Sciences*, *107*(21), 9485-9489.

Zimba, P.V. and Grimm, C.C. 2003. A synoptic survey of musty/muddy odor metabolites and microcystin toxin occurrence and concentration in southeastern USA channel catfish (Ictalurus punctatus Ralfinesque) production ponds. Aquaculture, 218(1-4): 81-87.

Appendix A – 24-hour Diet Recall Form

Time	Type of meal	Quick list	Food ingredients	Amount	Source
	☐Breakfast ☐Brunch ☐Lunch ☐Dinner ☐Late night meal ☐Tea/Snack				
	☐Breakfast ☐Brunch ☐Lunch ☐Dinner ☐Late night meal ☐Tea/Snack				
	☐Breakfast ☐Brunch ☐Lunch ☐Dinner ☐Late night meal ☐Tea/Snack				
	☐Breakfast ☐Brunch ☐Lunch ☐Dinner ☐Late night meal ☐Tea/Snack				
	☐Breakfast ☐Brunch ☐Lunch ☐Dinner ☐Late night meal ☐Tea/Snack				
	☐Breakfast ☐Brunch ☐Lunch ☐Dinner ☐Late night meal ☐Tea/Snack				

Introduction:

I need to find out what you have eaten the previous day. Please tell me everything that you have eaten including drinks, snacks, sauces, spices, and salad dressings. There is no right or wrong answer in this interview; you only need to tell me what you have actually eaten. Do you have any questions? If not, let's start.

-

Interview steps:

-

1. Time

What time did you wake up yesterday?

2. Quick List

Please tell me everything you ate or drank, as soon as you wake up at [insert time woke up here] yesterday morning.

-

[Do not interrupt unnecessarily.]
[When respondent stops, ask:] ***Anything else?***

- 3. Food Ingredients
-
- [Probe for additions to the food/drink. Ask about the ingredients and details.]
-

Now, I'm going to ask you more details about the foods and beverages you just listed.
What was the (food) you (ate/drank) made of?
What food ingredients were in the (meal or dish)?
Did it have any other ingredients? [If yes] ***What were they?***

4. Amount

-

Can you tell me how much did you eat [insert items from Quick List] yesterday? You can use these measuring guides and food pictures for the size or weight of foods.

-

5. Food Source

Where did you obtain the (food)?

-
- 6. Go to the next food item on the Quick List.

a. Go through all items on the Quick List.

- [Skip this step and go to step 7 when all foods in the Quick List have been asked]
-

7. Time

-
- ***What time was your next meal after eating at [time]?***
-
- 8. Go through steps 2 to 7.
-

9. Food break and review: ***Now let's see what you ate between meals and if I have everything; when you***

remember anything else you ate or drank as we go along, please tell me:

- a. ***What was the first food or drink you had after waking up yesterday? (Time?) (Type of meal?)***
- b. ***Now at (Time) for (This type of meal) you had (Foods), did you have anything else?***
- c. ***Did you have anything to eat or drink between your (Time) (This type of meal) and (Time) when you had***
- ***(Next type of meal)? Such as snacks, deserts, fruits or drinks?***
-

[Repeat 9b and 9c for each type of meal except the last one. For last meal, go to 9d.]

-

- d. ***Now at (Time) for (Last type of meal) you had (Foods)***, ***did you have anything else?***
- e. ***Did you have anything to eat or drink between your (Time) (Last type of meal) and waking up today?***
-

I'd like you to try to remember anything else you ate or drank yesterday, that you haven't already told me
about, including anything you ate or drank while preparing a meal or while waiting to eat.

-

[When respondent says no, or when respondent stops, ask]

10.***Did you eat the following foods?***

- [Be aware of cultural sensitivity when ask.]

-

a. Beef?

b. Pork?

c. Fish and seafood?

d. Chicken?

e. Mutton/Lamb?

f. Eggs?

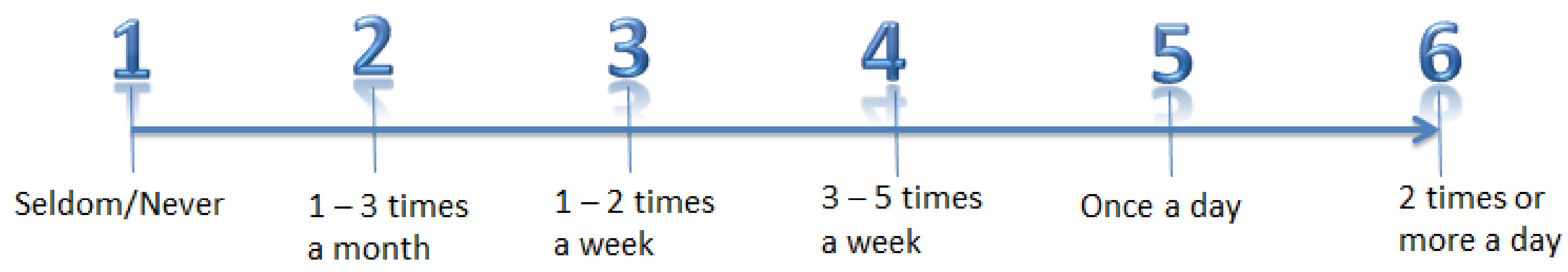
11. ***How frequent do you eat [insert items from Q10]? You have options from 1 to 6.*** Show card 1.

Go through all items reported on the list from Q10.

-
- 12. ***Thank you for your cooperation!***

Appendix C – Handout for 24-hour Dietary Recall

-



Appendix D - **FOOD FREQUENCY QUESTIONNAIRE**

Height: ………………………cm Weight: …………………… kg Respondent no.: ……………………………

Age: ……………………… years Gender: M ☐ F ☐ Date: …………………………………………..

Code	Food Type A. Cereal & cereal product	Frequency of intake Time per day	Time per week	Time per month	Time per year	Never	Serving size	How many serving per intake
A1	Plain rice						Scoop	
A2	Coconut rice						Scoop	
A3	Fragrant yellow rice						Scoop	
A4	Fried rice						Scoop	
A5	Porridge						Cup	
A6	Yellow/ wantan noodle						Cup	
A7	Rice noodle/ vermicelli/ laksa						Cup	
A8	Pasta						Cup	
A9	Instant noodle						Packet	
A10	Bread						Piece	
A11	Stuffed bun						Piece	
A12	Roti canai						Piece	
A13	Capati						Piece	
A14	Tosai						Piece	
A15	Naan						Piece	
A16	Breakfast cereal						Cup	
A17	Instant cereal						Sachet	
							Tablespoon	
A18	Oats						Tablepoon	
A19	Pizza						Slice	

Code	Food Type	Frequency of intake					Serving size	How many serving per intake
	B. Meat & meat product	Time per day	Time per day	Time per day	Time per day	Time per day		
B1	Chicken (Skin-on)						Piece	
B2	Chicken (Skinless)						Piece	
B3	Beef						Piece	
B4	Lamb/Mutton						Piece	
B5	Pork (lean)						Piece	
B6	Pork (streaky)						Piece	
	Duck (Skin-on)						Piece	
B7	Duck (Skinless)						Piece	
B8	Burger patty						Piece	
B9	Sausage/ hotdog/ frankfurter						Piece	
B10	Nugget						Piece	
B11	Meat ball of chicken/ crab/ prawn						Piece	
B12	Crab Stick						Piece	
B13	Offal						Piece	

[a]Cook in gravy [b]Deep-fried [c]Stir fried [d]Steamed [e]Poached [f]Roast/grill/baked

Code	Food Type	Frequency of intake					Serving size	How many serving per intake
	C. Fish and seafood product	Time per day	Time per day	Time per day	Time per day	Time per day		
C1								
C2								
C3								
C4								
C5								
C6								
C7								
C8								
C9								
C10								
C11								
C12								
C13								
C14								
C15								
C16								
C17								
C18								
C19								
C20								

[a]Cook in gravy [b]Deep-fried [c]Stir fried [d]Steamed [e]Poached [f]Roast/grill/baked

Code	Food Type	Frequency of intake					Serving size	How many servings per intake
	D. Egg	Time per	Time per week	Time per	Time per year	Never		

		day		month				
D1	Hen egg AA,B,C,D,E						Whole	
D2	Duck egg						Whole	
D3	Quail egg						Whole	
D4	Salted egg						Whole	

Code	**Food Type**	**Frequency of intake**					**Serving size**	**How many servings per intake**
	E. Legumes and Pulse	Time per day	Time per week	Time per month	Time per year	Never		
E1	Peas/Beans/ Lentils						Cup	
E2	Tofu						Piece	
E3	Tempe						Piece	
E4	Nuts						Tablespoon	

Code	**Food Type**	**Frequency of intake**					**Serving size**	**How many servings per intake**
	F. Milk & dairy product	Time per day	Time per week	Time per month	Time per year	Never		
F1	Fresh milk/ UHT						Cup	
							Glass	
F2	Milk powder						Tablespoon	
F3	Evaporated Milk						Tablespoon	
F4	Condensed Milk						Tablespoon	
F5	Yogurt						Cup	
F6	Cheese						Slice	

Code	Food Type	Frequency of intake					Serving size	How many servings per intake
	G. Vegetables	Time per day	Time per week	Time per month	Time per year	Never		
G1	Green leafy						Cup	
G2	Legumes						Cup	
G3	Root vegetables						Cup	
G4	Cruciferous						Cup	
G5	Melon/ Gourd						Cup	
G6	Corn kernel						Tablespoon	
G7	Wet/dried mushroom						Cup	
G8	Bean sprouts						Cup	

Code	Food Type	Frequency of intake					Serving size	How many servings per intake
	H. Fruits	Time per day	Time per week	Time per month	Time per year	Never		
H1	Fresh cut						Cup	
H2	Canned fruit						Cup	
H3	Dried fruit						Cup	

Code	Food Type	Frequency of intake					Serving size	How many servings per intake
	I. Beverages	Time per day	Time per week	Time per month	Time per year	Never		
I1	Coffee						Cup	
I2	Chocolate drink e.g.: Milo						Cup	
I3	Cordial syrup						Cup	
I4	Fruit juice						Cup	
I5	Low calorie carbonated drink e.g.: 100plus						Cup	
I6	High calorie carbonated drink e.g.: coca cola						Can	
I7	Soybean drink/ curd						Cup	
I8	Energy drink						Can	

Code	Food Type	Frequency of intake					Serving	How many servings per intake
	J. Confections	Time per day	Time per week	Time per month	Time per year	Never		
J1	Local kuih						Piece	
J2	Cake						Potong	
J3	Biscuits						Piece	
J4	Sweets						Piece	
							Potong	
J5	Ice-cream (dairy)						Cup	
							Scoop	
J6	Agar-agar/ jelly/ custard						Cup	
							Batang	
J7	Snack/ crackers						Piece	

Code	Food Type	Frequency of intake					Serving size	How many servings per intake
	K. Bread spread	Time per day	Time per week	Time per month	Time per year	Never		
K1	Jam						Tablespoon	
K2	Seri kaya						Tablespoon	
K3	Butter						Tablespoon	
K4	Margerine						Tablespoon	
K5	Peanut butter						Tablespoon	
K6	Cream cheese						Tablespoon	

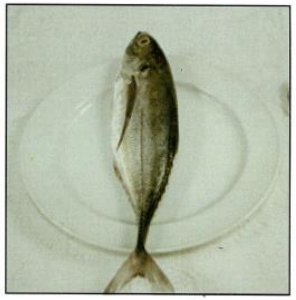
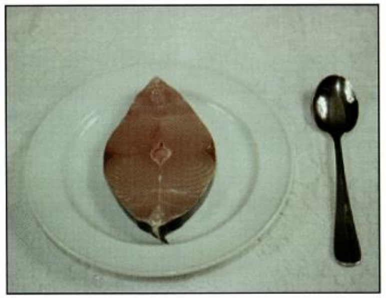
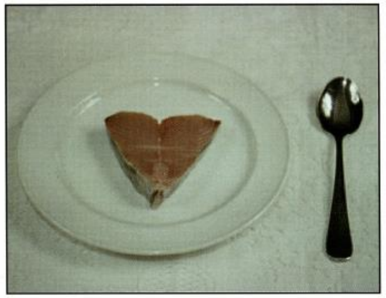
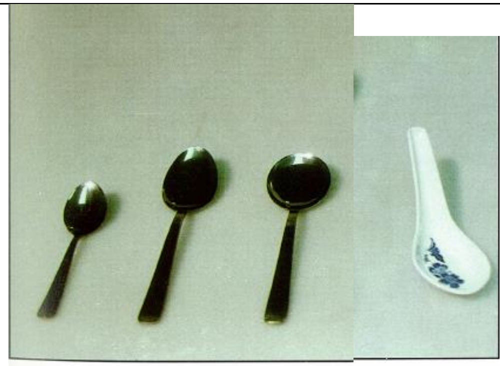
Code	Food Type	Frequency of intake					Serving size	How many servings per intake
	L. Condiments	Time per day	Time per week	Time per month	Time per year	Never		
L1	Sugar						Teaspoon	
L2	Honey						Teaspoon	
L3	Sambal belacan						Tablespoon	
L4	Budu/Cencaluk						Teaspoon	
L5	Fish sauce						Teaspoon	
L6	Petis/ heko/ otak udang						Teaspoon	

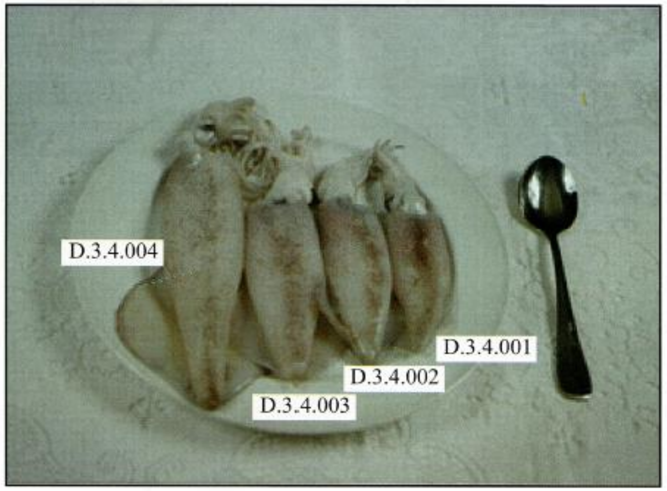
	Name	Serving Size	Frequency
Supplements			

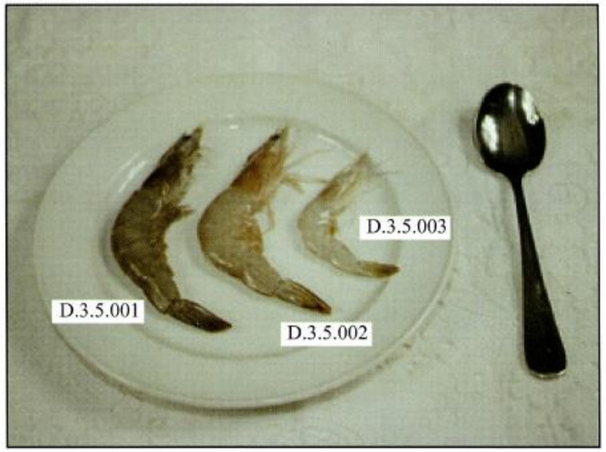
Oil usage per month: ______________________ Salt usage per month: ______________________

Code	A. Meat & meat product	
A1	Chicken (Skin-on)	 D.3.2.001  D.3.2.002  D.3.2.003  D.3.2.004  B.2.001
A2	Chicken (Skinless)	
A3	Beef	 B.2.002  D.3.6.005
A4	Lamb/Mutton	
A5	Pork (lean)	 B.2.002  D.3.6.005
A6	Pork (streaky)	
A7	Duck (Skin-on)	 D.3.2.001  D.3.2.002  D.3.2.003  D.3.2.004  B.2.001
A8	Duck (Skinless)	

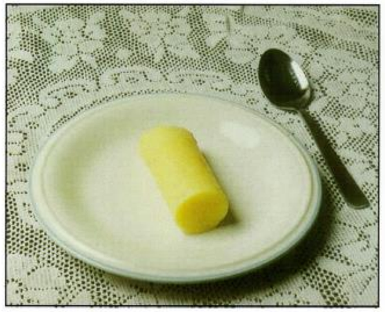
A9	Offal	 B.2.003
A10	Burger patty	How many pieces?
A11	Sausage/ hotdog/ frankfurter	How many pieces?
A12	Nugget	How many pieces?
A13	Meat ball of chicken/ beef	How many pieces?

Code	B. Fish & fish product
 D.3.3.001  D.3.3.002  D.3.3.003  D.3.3.004  D.3.3.008  D.3.3.009  D.3.3.010	 Sudu teh *Tea spoon* 5ml Sudu makan *Dessert spoon* 10ml Sudu sup *Soup spoon* 10ml Sudu cina *Chinese scoop* 20ml

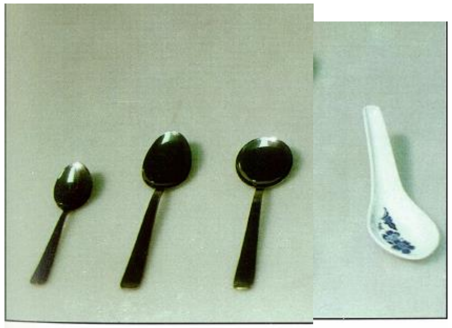




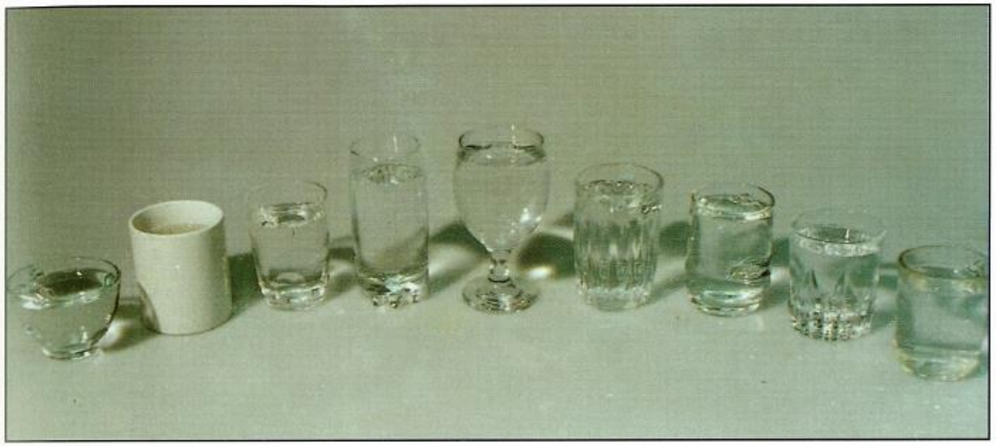
D.3.5.001, D.3.5.002, D.3.5.003

Code	D. Legumes and Pulse	
D1	Peas/Beans/ Lentils	
D2	Nuts	
D3	Tofu	 B.1.013  B.1.014  B.1.015
D4	Tempe	

Code	E. Milk and Dairy Product
E1	Fresh milk/ UHT
	Milk powder
E2	Evaporated Milk
E3	Condensed Milk
E4	Yogurt



Sudu teh *Tea spoon* 5ml | Sudu makan *Dessert spoon* 10ml | Sudu sup *Soup spoon* 10ml | Sudu cina *Chinese scoop* 20ml



150ml 280ml 200ml 350ml 300ml 300ml 250ml 200ml 200ml

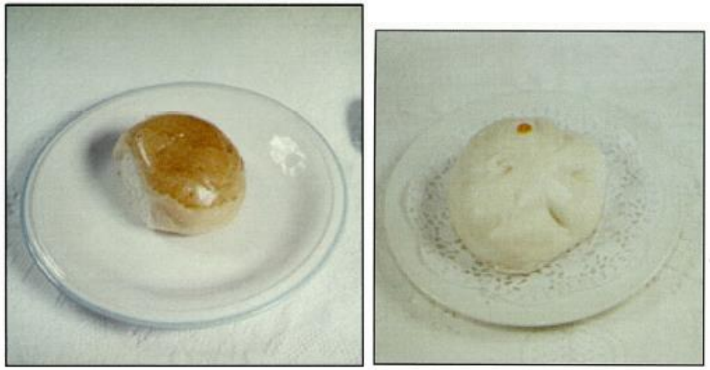
<table>
<tr><th>Code</th><th colspan="2">F. Cereal & cereal product</th></tr>
<tr><td>F1</td><td>Plain rice</td><td rowspan="4">

D.1.1.001
Piring kuih
Side plate
D=19.5cm

D.1.1.002
Pinggan makan
Plate
D=27.5cm

D.1.1.003
Mangkuk
Bowl
D=20cm

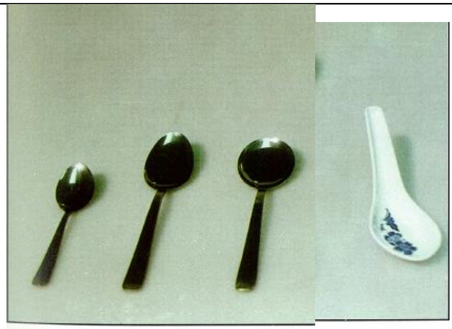
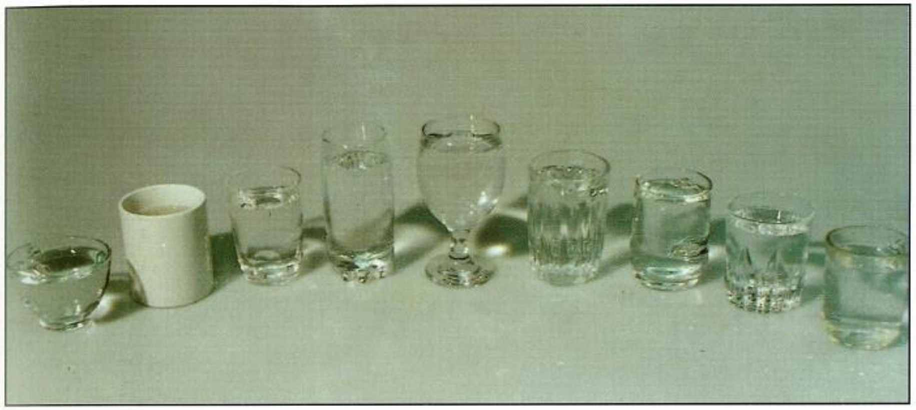
Piring sos
Sauce plate
D=9.5cm
Mangkuk cina kecil
Small chinese bowl
D=9cm
V=150ml
Mangkuk cina sederhana
Medium chinese bowl
D=11cm
V=250ml
Mangkuk cina besar
Large chinese bowl
D=13cm
V=450ml
</td></tr>
<tr><td>F2</td><td>Coconut rice/ yellow rice</td></tr>
<tr><td>F3</td><td>Fried rice</td></tr>
<tr><td>F4</td><td>Porridge</td></tr>
</table>

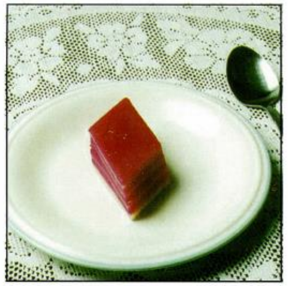
F5	Yellow/ wantan noodle	
F6	Rice noodle/ vermicelli/ laksa	
F7	Pasta	 E.3.006
F8	Instant noodle	How many packets/cups?
F9	Plain toast	
F10	Stuffed bun	

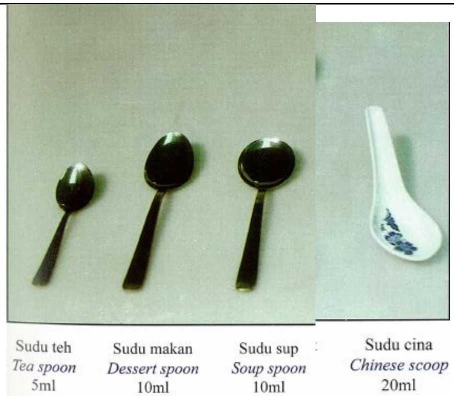
F11	Roti canai/ Capati/ Tosai/ Naan	
F12	Breakfast cereal	
F13	Oats	
F14	Pizza	 E.3.004 b

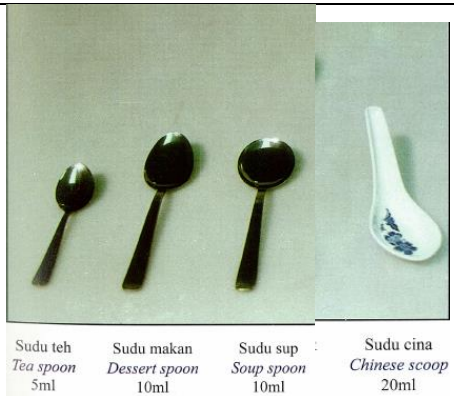
Code	G. Vegetables	
G1	Green leafy/ Cruciferous	 
G2	Legumes	
G3	Potato [a/b]	
G4	Corn kernel	
G5	Wet/dried mushroom	
G6	Bean sprouts	

Code	H. Fruits	
H1	Fresh cut	
H2	Canned fruit	
H3	Dried fruit	

Code	I. Beverages	
I1	3-in-1 Coffee	How many sachets?
I2	Chocolate drink e.g.: Milo	 Sudu teh *Tea spoon* 5ml; Sudu makan *Dessert spoon* 10ml; Sudu sup *Soup spoon* 10ml; Sudu cina *Chinese scoop* 20ml
I3	Instant cereal e.g. Nestum	
I4	Cordial syrup	 150ml 280ml 200ml 350ml 300ml 300ml 250ml 200ml 200ml
I5	Fruit juice	
I6	Fizzy drink e.g.: coca cola	
I7	Soybean drink/ curd	

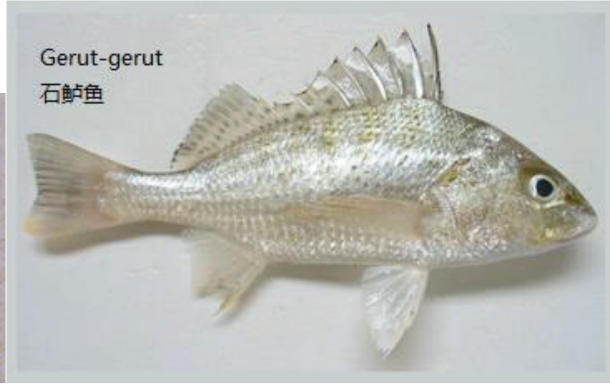
Code	J. Confections	
J1	Local kuih	 
J2	Cake	
J3	Biscuits	How many pieces?
J4	Ice-cream (dairy)	 Sudu teh *Tea spoon* 5ml; Sudu makan *Dessert spoon* 10ml; Sudu sup *Soup spoon* 10ml; Sudu cina *Chinese scoop* 20ml
J5	Agar-agar/ jelly/ custard	
J6	Snack/ crackers	How many pieces?

Code	K. Bread spread	
K1	Jam	
K2	Seri kaya	
K3	Butter	
K4	Margerine	
K5	Peanut butter	
K6	Cheese	How many slices?

Code	L. Condiments	
L1	Sugar	
L2	Honey	

Appendix F - FFQ Fish Photo


Bulus
沙钻


Gerut-gerut
石鲈鱼

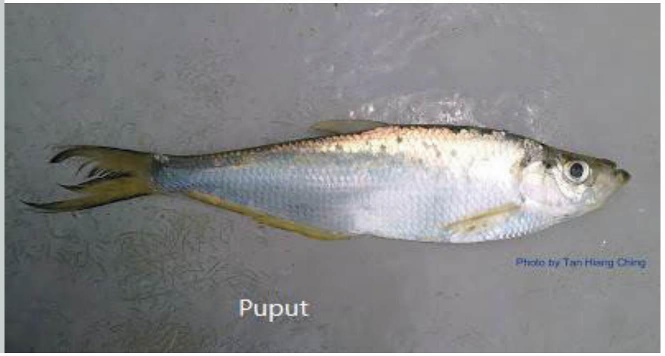


Photo by Tan Hiang Ching
Puput


Kerisi
红哥里
Photo by Tan Hiang Ching


Mabong


Mata Besar
大目
Photo by Tan Hiang Ching


Selar 色拉

Tilapia Merah
红非洲


Kerapu Kertang
龙趸
Photo by Tan Hiang Ching


Kerapu Bunga
花斑
Photo by Tan Hiang Ching


Kerapu Coklat
石斑魚
Photo by Tan Hiang Ching


Kerapu Merah
七星斑
Photo by Tan Hiang Ching


Jenahak
红皂
Photo by Tan Hiang Ching


Merah 红鱼


Kurau 顺风鱼


Susu
牛奶鱼/虱目鱼
Photo by Tan Hiang Ching


Mayong
咸水白须公


Terubok
三尼鱼
Photo by Tan Hiang Ching


Senangin
马友


Delah/Tauhu
豆腐鱼


Tongkol
柴鱼


Parang 西刀鱼


Tenggiri
鲛鱼

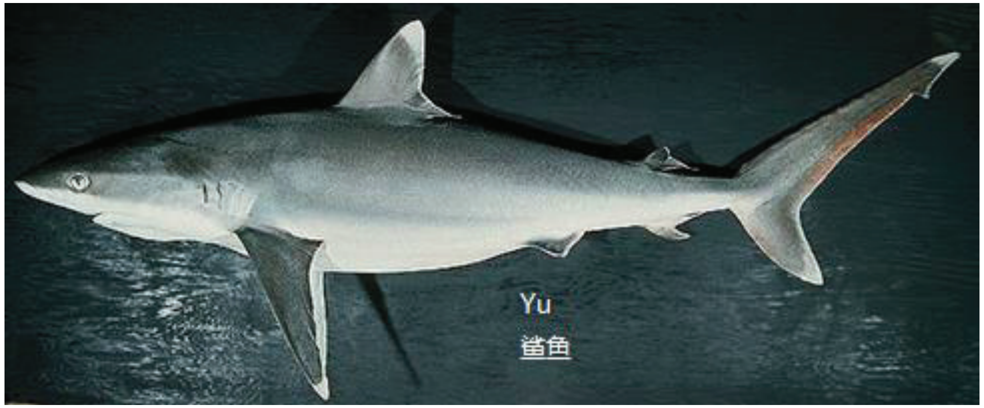

Pari
魔鬼鱼 / 蒲鱼


Nyok-nyok
镜鲳


Ikan Sepat
蛇皮马甲


Sebelah
左口鱼


Malong
海鳗



Salmon
三文鱼

Udang Galah 生虾 / 大头虾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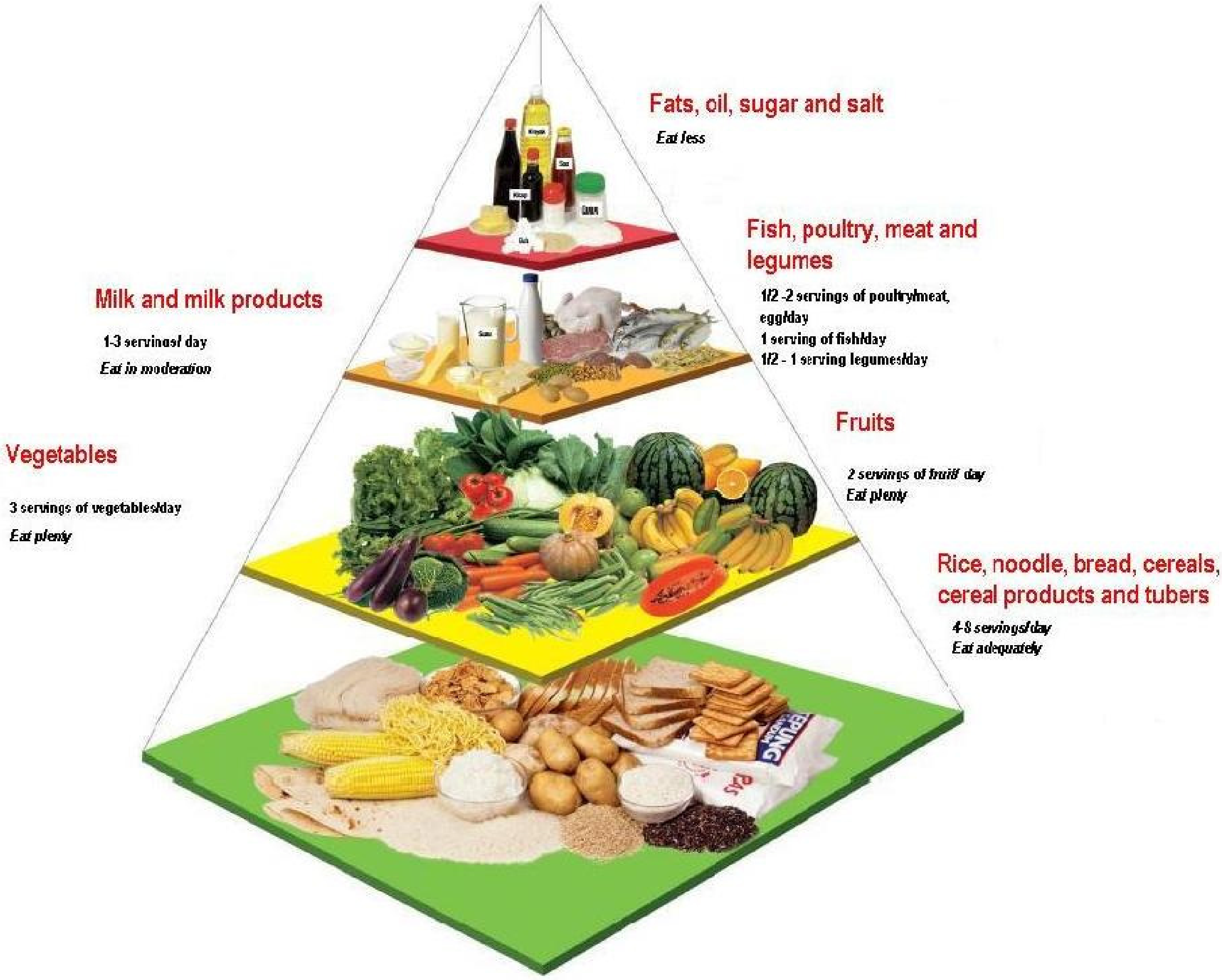
Appendix G – Malaysian Dietary Guideline (1)



Ministry of Health (2010). Malaysian Dietary Guidelines. Nutrition Division, Ministry of Health Malaysia, Putrajaya.

Appendix H – Malaysian Dietary Guideline (2)

Food group	1500 kcal/day	2000 kcal/day	2500 kcal/day
Cereals and grains	4 servings [1]	6 servings [1]	8 servings [1]
Fruits	2 servings	2 servings	2 servings
Vegetables	3 servings	3 servings	3 servings
Meat/poultry	½ serving [2]	1 serving [2]	2 servings [2]
Fish	1 serving [2]	1 serving [2]	1 serving [2]
Legumes	½ serving [3]	1 serving [3]	1 serving [3]
Milk and dairy products	1 serving [3]	2 serving [3]	3 serving [3]

1 Based on 30 g carbohydrate per serving

2 Based on 14 g protein per serving

3 Based on 7 g protein per serving

Table: Distribution of number of servings according to food groups based on calorie value

Appendix I – Latin Names of Commonly Consumed Fish in Malaysia

No	English Name	Latin Name
1	Anchovies	*Stolephorus spp.*
2	Barramundi	*Lates calcarifer*
3	Big Head Carp[pf]	*Hypophthalmichthys nobilis*
4	Black Pomfret	*Parastromateus niger*
5	Blood Cockles	*Anadara granosa*
6	Catfish[pf]	*Clarias batrachus*
7	Fourfinger Threadfin	*Eleutheronema tetradactylum*
8	Hardtail Scad	*Megalaspis cordyla*
9	Indian Mackerels	*Rastrelliger kanagurta*
10	Lala Clam	*Orbicularia orbiculata*
11	Red Snapper[p]	*Lutjanus campechanus*
12	Red Tilapia	*Oreochromis spp.*
13	Round Scad	*Selaroides leptolepis*
14	Salmon[p]	*Salmo salar*
15	Sardine	*Sardinella spp*
16	Small Tuna	*Euthynnus affinis*
17	Sole Fish	*Pseudorhombus Arsius*
18	Spanish Mackerels	*Scomberomorus commerson*
19	Stingrays	*Dasyatidae spp.*
20	Threadfin Bream	*Nemipterus bathybius*
21	Tiger Prawns	*Penaeus monodon*
22	Vannamei Prawn	*Penaeus vannamei*
23	White Pomfret	*Pampus argenteus*

Appendix J – Wholesaler Survey Questionnaire

Hello. My name is Ee Von. I am a PhD candidate from University of Nottingham. We are conducting a marketing survey about important issues facing the fisheries today. We are not selling anything or raising money. The survey is completely confidential. (IF ASK: The survey takes at least 10 minutes.) May I please speak to the operation manager or purchasing manager or person who take charge of the stocks of fishery products? (IF NECESSARY ARRANGE FOR AN APPOINTMENT AND RECORD DATE AND TIME. REPEAT INTRO. AS NECESSARY)

****

I am going to ask your opinion about the current fishing industry and its market, which includes the production and sales of wild-caught and farmed fish. In the following survey, I will be using the term, aquatic animal products. Aquatic animal products would mean all fin-fish, shellfish and crustaceans, derived freshwater and marine water, by farming and wild capture, and the by-product s and products derived from them.

First, I would like to learn more about your farm and its operation.

1. Can I know what are the species that the company farms?

Click here to enter text.

2. In what form are the products marketed as? ***Prompt. Respondents may choose more than one.***

☐ live

☐ fresh

☐ frozen

☐ prepared and/or ready to eat

☐ dried or cured

☐ other, specify: Click here to enter text.

3. Who are your primary customers? ***Prompt. Respondents may choose more than one.***

☐ Independent retailers

☐ Chained retailers

☐ Restaurants/ Canteen

☐ Wholesalers

☐ Processors/Exporters

☐ The company-owned retailers. State number of premises: Click here to enter text.

☐ Oversea location, specify: Click here to enter text.

☐ other, specify: Click here to enter text.

4.1 I will read out the attributes of aquatic animal. Can you please tell me if you think farmed aquatic animal products are superior, worse or indifferent in each of the following attributes, when compared to wild-caught aquatic animal products.

Attribute	**Superior**	**The same**	**Worse**	**Don't know**
Availability throughout the year	☐	☐	☐	☐
Uniformity of sizes	☐	☐	☐	☐
Freshness	☐	☐	☐	☐
Quality	☐	☐	☐	☐
Appearance	☐	☐	☐	☐
Contaminant content	☐	☐	☐	☐
Scent or smell	☐	☐	☐	☐
Flavour or taste	☐	☐	☐	☐
Shelf life	☐	☐	☐	☐
Price stability	☐	☐	☐	☐
Customer preference	☐	☐	☐	☐
Texture	☐	☐	☐	☐
Customers' perceived value	☐	☐	☐	☐
Price satisfaction	☐	☐	☐	☐
Health benefits	☐	☐	☐	☐

4.2 Is there any attributes that you think are superior in farmed aquatic animal than in wild aquatic animal?

Click here to enter text.

4.3 Is there any attributes that you think are worse in farmed aquatic animal than in wild aquatic animal?

Click here to enter text.

For respondent who answered that farmed product is worse in customer preference, ask:

4.4.1 I noticed that you said more customers prefer wild-caught aquatic animal than farmed aquatic animal. Why do you think more customers would prefer wild-caught aquatic animal than farmed aquatic animal?

Click here to enter text.

For respondent who answered that farmed product is better in customer preference, ask:

4.4.2 I noticed that you said more customers prefer farmed aquatic animal than wild-caught aquatic animal. Why do you think more customers would prefer farmed caught aquatic animal than wild-caught aquatic animal?

Click here to enter text.

For respondent who answered that farmed and wild products are the same in terms of customer preference, ask:

4.4.3 I noticed that you said customers prefer wild-caught aquatic animal as much as farmed aquatic animal. What are the reasons you think customer preference in wild-caught or farmed aquatic animal is indifferent?

Click here to enter text.

5. Is your operation currently producing enough to meet sales demand?

☐ Yes

☐ No

If No, ask:

5.1 Why is the current operation not able to meet sales demand?

Click here to enter text.

6. If you were to double the size of your aquaculture business, what do you think are the barriers that you have to first overcome? ***Prompt. Respondents may choose more than one.***

☐ Involvement of central agency

☐ Climate change

☐ Low market needs

☐ Importing country requirements

☐ Disease threat

☐ Dependence on imported raw material for formulated feed

☐ Competition among other producers

☐ Economic down turn

☐ Other, specify: Click here to enter text.

For respondent who gave answer related to low market needs, ask:

6.1 What do you think are the major factors that cause low market needs of farmed aquatic animal from consumer?

Click here to enter text.

7. What are the existing or emerging trends and factors that you think are exploitable opportunities to help expand your aquaculture business? ***Prompt. Respondents may choose more than one.***

☐ Global demand of fish due to health consciousness

☐ Natural fish resources declining worldwide

☐ Newest aquaculture technologies available

☐ New demand for live organic fish/seafood

☐ Increasing demand on Halal product

☐ Other, specify: Click here to enter text.

We are about to finish the questionnaire. To help us categorise the data better, I need to get more information about your business.

8. What is the size of your aquaculture farm, in terms of hectare?

Click here to enter text.

9. How much was your total production in year 2013, in terms of metric tonnes?

Click here to enter text.

10. What is the number of employees, both temporary and permanent, you currently engage?

Click here to enter text.

11. How much was your total revenue in year 2013, in terms of RM?

Click here to enter text.

12. Can I please confirm your name and your designation in the company?

Click here to enter text.

The survey has ended. Thank you for your time and cooperation.

Appendix K – Aquaculturist Survey Questionnaire

Hello. My name is Ee Von. I am a PhD candidate from University of Nottingham. We are conducting a marketing survey about important issues facing the fisheries today. We are not selling anything or raising money. The survey is completely confidential. (IF ASK: The survey takes at least 10 minutes.) May I please speak to the operation manager or purchasing manager or person who take charge of the stocks of fishery products? (IF NECESSARY ARRANGE FOR AN APPOINTMENT AND RECORD DATE AND TIME. REPEAT INTRO. AS NECESSARY)

****

I am going to ask your opinion about the current fishing industry and its market, which includes the production and sales of wild-caught and farmed fish. In the following survey, I will be using the term, aquatic animal products. Aquatic animal products would mean all fin-fish, shellfish and crustaceans, derived freshwater and marine water, by farming and wild capture, and the by-product s and products derived from them.

First of all, I would like to learn more about your business and its operation.

1. Can I know which forms of aquatic animal products do you sell? ***Prompt. Respondents may choose more than one.***

☐ live

☐ fresh

☐ frozen

☐ prepared and/or ready to eat

☐ dried or cured

Proceed to Q3 if less than two answers given for Q1.

2. Can you please rank the forms of product in terms of largest volume sold? 1 being the largest amount sold while 2 being the second largest and so forth.

Click here to enter text.live
Click here to enter text.fresh
Click here to enter text.frozen
Click here to enter text.prepared and/or ready to eat
Click here to enter text.dried or cured

Ask respondents to only rank the forms of product that they sell.

3. In 2013, what were your five best-selling aquatic animal items/species, in terms of largest volume sold, that were

	☐ live	☐ fresh	☐ frozen	☐ prepared and/or ready to eat	☐ dried or cured
i.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.
ii.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.
iii.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.
iv.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.
v.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.

4. What are the sources of your aquatic animal products? ***Prompt. Respondents may choose more than one.***

☐ wholesale fish market

☐ central warehouse

☐ major seafood wholesaler

☐ directly from the boats or primary producer of local origin

☐ import from oversea location

☐ from own fish farm

☐ from own fish catch

☐ value-added process/fabricate ourselves

☐ other, specify: Click here to enter text.

5. Who are your primary customers? ***Prompt. Respondents may choose more than one.***

☐ Independent retailers

☐ Chained retailers

☐ Restaurants/ canteens

☐ Wholesalers

☐ Processors/Exporters

☐ Oversea location

☐ Other, specify: Click here to enter text.

6. Do you ever use farm-raised aquatic animal products? Farm-raised can also be understood as aquacultured.

☐ Yes ***– Proceed to Q6.1.1. Skip Q6.2.***

☐ No ***– Proceed to Q6.2***

6.1.1 If so, how many percent of total aquatic animal products you use are farmed-raised?

Click here to enter text.

6.1.2 Can you name the products/species?

Click here to enter text.

6.1.3 Do you include the term “farm raised” or “aquacultured as a marketing tool?

☐ Yes

☐ No

6.2 If never, why do you not use farmed-raised products?

Click here to enter text.

7. 1 I will read out the attributes of aquatic animal. Can you please tell me if you think farmed aquatic animal products are superior, worse or indifferent in each of the following attributes, when compared to wild-caught aquatic animal products.

Attribute	Superior	The same	Worse	Don’t know
Availability throughout the year	☐	☐	☐	☐
Uniformity of sizes	☐	☐	☐	☐
Freshness	☐	☐	☐	☐
Quality	☐	☐	☐	☐
Appearance	☐	☐	☐	☐
Contaminant content	☐	☐	☐	☐
Scent or smell	☐	☐	☐	☐
Flavour or taste	☐	☐	☐	☐

Shelf life	☐	☐	☐	☐
Price stability	☐	☐	☐	☐
Customer preference	☐	☐	☐	☐
Texture	☐	☐	☐	☐
Customers' perceived value	☐	☐	☐	☐
Price satisfaction	☐	☐	☐	☐
Health benefits	☐	☐	☐	☐

7.2 Is there any attributes that you think are superior in farmed aquatic animal than in wild aquatic animal?

Click here to enter text.

7.3 Is there any attributes that you think are worse in farmed aquatic animal than in wild aquatic animal?

Click here to enter text.

For respondent who answered that farmed product is worse in customer preference, ask:

7.4.1 I noticed that you said more customers prefer wild-caught aquatic animal than farmed aquatic animal. Why do you think more customers would prefer wild-caught aquatic animal than farmed aquatic animal?

Click here to enter text.

For respondent who answered that farmed product is better in customer preference, ask:

7.4.2 I noticed that you said more customers prefer farmed aquatic animal than wild-caught aquatic animal. Why do you think more customers would prefer farmed aquatic animal than wild-caught aquatic animal?

Click here to enter text.

For respondent who answered that farmed and wild products are the same in terms of customer preference, ask:

7.4.3 I noticed that you said customers prefer wild-caught aquatic animal as much as farmed aquatic animal. What are the reasons you think customer preference in wild-caught or farmed seafood is indifferent?

Click here to enter text.

8. If you wanted to double the sales (start selling) of farmed aquatic animal products, what do you think are the barriers that you have to overcome? ***Prompt. Respondents may choose more than one.***

☐ Shortage of farmed product supply – seafood farmers are not producing enough

☐ Low market needs

☐ Importing country requirements

☐ Economic down turn

☐ Competition among other wholesalers/processors

☐ Other, specify: Click here to enter text.

For respondent who gave answer related to low market needs, ask:

8.1 What do you think are the major factors that cause low market needs of farmed aquatic animal from consumer?

Click here to enter text.

9. What are the existing or emerging trends and factors that you think are exploitable opportunities to help increase the sales of your farmed products? ***Prompt. Respondents may choose more than one.***

☐ Global demand of fish due to health consciousness

☐ Natural fish resources declining worldwide

☐ Newest aquaculture technologies available

☐ New demand for live organic fish/seafood

☐ Increasing demand on Halal product

☐ Other, specify: Click here to enter text.

We are about to finish the questionnaire. To help us categorise the data better, I need to get more information about your business.

11. What is the number of employees, both temporary and permanent, you currently engage?

Click here to enter text.

12. How much was your total revenue in year 2013, in terms of RM?

Click here to enter text.

13. Can I please confirm your name and your designation in the company?

Click here to enter text.

The survey has ended. Thank you for your time and cooperation.

Appendix L – Consumer Survey Questionnaire

Your completion of this questionnaire constitutes your consent to use your results. There are no right or wrong answers, and your responses are anonymous, so please be as honest as you can. If you are unsure about how to answer a question, please choose what you feel is the best response and answer all of the questions.

1. How often do you consume seafood that you prepare at home?

☐ Seldom/Never

☐ 1-3 times a month

☐ 1-2 times a week

☐ 3-5 times a week

☐ Once a day

☐ 2 times or more a day

2. How often do you consume seafood out of home?

☐ Seldom/Never

☐ 1-3 times a month

☐ 1-2 times a week

☐ 3-5 times a week

☐ Once a day

☐ 2 times or more a day

3. Please look at the following reasons why you might choose to consume seafood. Please tick the appropriate box for each reason according to their degree of importance to you. There is no right or wrong answer. Please choose the answer which represents your opinion.

		Not at all important	Slightly important	Moderately important	Extremely important
i	I like the taste.	☐	☐	☐	☐
ii	Family members like fish.	☐	☐	☐	☐
iii	I believe it is a healthy food.	☐	☐	☐	☐
iv	I believe it is low calorie.	☐	☐	☐	☐
v	I think it is easy to prepare.	☐	☐	☐	☐
vi	I like its 'gourmet appeal'.	☐	☐	☐	☐
vii	I find new recipes that I'd like to try.	☐	☐	☐	☐
viii	I'd like to have a variety in my diet.	☐	☐	☐	☐
ix	Seafood is very affordable.	☐	☐	☐	☐

4. Please look at the following reasons why you might not choose to consume seafood. Please tick the appropriate box for each of the statements below according to what degree you agree that is the reason why you might not choose to consume seafood. There is no right or wrong answer. Please choose the answer which represents your opinion.

		Disagree strongly	Disagree somewhat	Agree somewhat	Agree strongly
i	The supply of fresh fish is inconsistent or lacking.	☐	☐	☐	☐
ii	There are very limited seafood choices.	☐	☐	☐	☐
iii	Seafood is expensive.	☐	☐	☐	☐
iv	Some of my family members do not like fish.	☐	☐	☐	☐
v	I do not like the taste of fish.	☐	☐	☐	☐
vi	I find it difficult to tell whether the fish and seafood is fresh or not.	☐	☐	☐	☐
vii	It is difficult to clean and prepare the fish and seafood.	☐	☐	☐	☐
viii	It is difficult to cook fish.	☐	☐	☐	☐

ix	I don't like the smell when cooking fish.	☐	☐	☐	☐
x	Unlike other meat, fish lack of satiety after consuming it.	☐	☐	☐	☐

5. Where do you usually purchase seafood to prepare at home? (Check all that apply)

☐ Supermarket ☐ Specialty store ☐ Wet market

☐ Other, please specify: ____

6. When you get to the seafood counter, what are the most important factors in determining what to buy? Please tick the appropriate box. There is no right or wrong answer. Please choose the answer which represents your opinion.

		Not at all important	Slightly important	Moderately important	Extremely important
i	Product freshness	☐	☐	☐	☐
ii	Visual appeal	☐	☐	☐	☐
iii	Price	☐	☐	☐	☐
iv	Confidence in the seafood department	☐	☐	☐	☐
v	Knowledgeable counter personnel	☐	☐	☐	☐
vi	Availability of recipe information	☐	☐	☐	☐
vii	Already planned what to cook	☐	☐	☐	☐
viii	In-store demonstrations	☐	☐	☐	☐
ix	Samples	☐	☐	☐	☐
x	Availability of seafood that I am familiar with	☐	☐	☐	☐
xi	Availability of product origin information e.g. location, whether wild-caught or farmed, whether freshwater or marine water?	☐	☐	☐	☐

7. Please list the five seafood products that you purchase most often (include fresh, chilled, frozen, pre-packed and canned finfish and shellfish). State the frequency of consumption for each product.

	Name of seafood \ Frequency	1-3 times a month	1-2 times a week	3-5 times a week	Once a day	2 times or more a day
i	____________	☐	☐	☐	☐	☐
ii	____________	☐	☐	☐	☐	☐
iii	____________	☐	☐	☐	☐	☐
iv	____________	☐	☐	☐	☐	☐
v	____________	☐	☐	☐	☐	☐

8. Do you prefer wild seafood or aquacultured (farm raised) seafood?

☐ Wild

☐ Farmed

☐ No special preference

9. Have you ever purchased aquacultured (farm raised) seafood?

☐ Yes

If yes, please list out: ____

☐ No

☐ Not sure/ Don't know

If not sure/don't know, why? (Check all that apply)

☐ *Difficult to differentiate the farmed fish from the wild fish*

☐ *I never enquire about the origin of fish when I buy them*

☐ *There's no information available when I buy them*

☐ Other, please specify: ____

10. What perceptions do you have about aquacultured (farm raised) products in comparison to wild-caught products? Please tick the appropriate box. There is no right or wrong answer. Please choose the answer which represents your opinion.

Attribute	**Aquacultured is better**	**Wild-caught is better**	**Both are the same**	**Don't know/ Not sure**
Freshness	☐	☐	☐	☐
Quality	☐	☐	☐	☐
Appearance	☐	☐	☐	☐
Scent or smell	☐	☐	☐	☐
Flavour or taste	☐	☐	☐	☐
Texture	☐	☐	☐	☐
Shelf life	☐	☐	☐	☐
Uniformity of sizes	☐	☐	☐	☐
Availability throughout the year	☐	☐	☐	☐
Price stability throughout the year	☐	☐	☐	☐
Valued more in society	☐	☐	☐	☐
Value for money	☐	☐	☐	☐
Health benefits	☐	☐	☐	☐
Contaminant content	☐	☐	☐	☐
Environmental friendly	☐	☐	☐	☐
Sustainability	☐	☐	☐	☐

11. Please tick the appropriate box. Please choose the answer which represents your opinion.

		True	False	Not sure
i	Fish is a source of dietary fibre.	☐	☐	☐
ii	My friends consider me as an expert in the domain of fish.	☐	☐	☐
iii	Mackerel and tuna are freshwater fish.	☐	☐	☐
iv	One of the differences between farmed and wild fish is their ratios of omega 6 to omega 3 fatty acids.	☐	☐	☐
v	Fish is the largest contributor of saturated fat in our diet.	☐	☐	☐
vi	I know a lot about how to evaluate the quality of fish.	☐	☐	☐
vii	Compared to an average person, I know a lot about fish.	☐	☐	☐
viii	Fish is a source of unsaturated fats like omega-3 fatty acids	☐	☐	☐
ix	Salmon is a cold-water fish.	☐	☐	☐

12. What age group do you belong to?

☐ 18 – 29
☐ 30 – 39
☐ 40 – 49
☐ 50 – 59
☐ 60 – 69
☐ >70

13. What is your highest level of education?

☐ PMR
☐ SPM
☐ STPM/Pre-U
☐ Certificate/Diploma
☐ Bachelor's degree
☐ Postgraduate

14. Which category of occupation do you belong to?

☐ Higher managerial, administrative, professional e.g. chief executive, senior civil servant, surgeon
☐ Intermediate managerial, administrative, professional e.g. bank manager, teacher
☐ Supervisory, clerical, junior managerial e.g. shop floor supervisor, bank clerk, sales person
☐ Skilled manual workers e.g. electrician, carpenter
☐ Semi-skilled and unskilled manual workers e.g. assembly line worker
☐ Inactive or long term unemployed
☐ Student

15. How many people are in your household, including yourself?

____

16. Your household income is estimated at:

☐ Below 2,000
☐ 2,000 – 2,999
☐ 3,000 – 3,999
☐ 4,000 – 4,999
☐ 5,000 – 5,999
☐ 6,000 – 6,999
☐ 7,000 – 7,999
☐ 8,000 – 8,999
☐ 9,000 – 9,999
☐ 10,000 and above

The survey has ended. Thank you.

Appendix M – Ethical Approval

UNMC Ethics Committee Reviewer Decision Form (version 2, Dec 2011)

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Ethics Committee Reviewer Decision

This form must be completed by each reviewer. Each application will be reviewed by at least two members of the Ethics Committee. Reviews should be completed electronically and emailed to the **Ethics Administrator** (ethics@nottingham.edu.my) from a University of Nottingham email address.

Applicant full name:	Ee Von Goh
Application identification number:	GEV120116, GEV110116

REVIEWED BY:

Reviewer ID:

Date:	18.01.16
Outcome:	Approved - no amendments required

Major amendments required:

The two projects that have been reviewed are both minimal risk projects. All questions in part B have been answered 'NO' except for question 5. Here the applicant declares that a small token of appreciation will be awarded to the study participants.
The consent form includes the mention of the reward.

Minor amendments required:

Comments: