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Responding to Changing Lifestyles Engineering the Convenience Foods

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28 NOVEMBER 2008

Dewan Taklimat
Bangunan Pentadbiran
Universiti Putra Malaysia

Penerbit Universiti Putra Malaysia
Serdang • 2008
http://www.penerbit.upm.edu.my

First Print 2008

UPM Press is a member of the Malaysian Book Publishers Association (MABOPA)
Membership No.: 9802

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Russly Abdul Rahman
Responding to changing lifestyles: engineering the convenience foods / Russly Abdul Rahman.
(Inaugural lecture series)
ISBN 978-967-344-025-2
1. Food industry and trade. 2. Speeches, addresses, etc. I. Title.
II. Series.
363.8

Design, layout and printed by

Penerbit Universiti Putra Malaysia
43400 UPM Serdang
Selangor Darul Ehsan
Tel: 03-8946 8855 / 8854
Fax: 03-8941 6172
http://www.penerbit.upm.edu.my

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INTRODUCTION

The consumer consumption trend today, is not the same as that of ten years ago. As times change, so do consumer eating habits and preferences primarily due to several factors. These factors are formed from the demand of more sophisticated consumers such as:

- Increase of working woman, single parent and dual income household
- Change in lifestyle (lighter meal, health and weight conciousness)
- Aging population
- Knowledgeable and educated citizens (food safety, nutrition, labelling)
- Return to organics
- Energy enhancing foods
- An eat-where-you-are society
- Desire of ethnic cuisine among various ethnic groups
- Demand for Halal recognition among Muslim community

The evolving lifestyle of consumers which has changed from a laidback lifestyle to a fast paced one has escalated the demand for time saving and convenient ways of preparation and cooking. Corollary to that is the increase in demand by working mothers for convenience food driving the innovation of chilled or frozen ready prepared meals. People suffering from certain diseases e.g. diabetes or coronary heart disease is another primary concern encouraging consumer demand for nutritional and health/functional food. Further, the growth of health conscious consumers has increased the need for more innovation and production of natural/organic and fresh food products. The desire among various ethnic groups for instance the Japanese, Indians, Polynesians, Mexicans, and

Jamaicans, for a variety of new and spicy flavoured food products has also played a major role in creating a marketing niche. In addition, requests for Halal food both in Malaysia and around the world has recently increased, creating another special niche.

CONVENIENCE FOOD TRENDS

The key to successful entry into the global food industry, valued at €3.2 trillion, is to understand the mega-trends which influence buying behavior chief of which is convenience. Time saving products such as prepared meals in Europe and USA are forecasted to double in ten years, to exceed US$50 billion by 2009 up from US$29 billion from 1999 (Anon, 2005)

INTERNATIONAL SCENARIO

The world trend towards ready prepared convenience food products is undeniable. Currently 62% of consumers buy frozen ready prepared/ready to-eat food compared to the 40% in 1980. According to one European source, various ranges of food products have been introduced in the market recently. Product categories with the highest growth rate are ready-to-eat frozen convenience food products at 13.3%. This phenomenon is due to a changing workforce with more and more working women and two-income households.

In the United State, the 47% of Americans who buy frozen ready prepared dinners form the largest segment of the $23.7 billion food industry and these households tend to be scattered all over the map. Demographic surveys show that the biggest fans are blue-collar families, older couples and retired singles particularly those living in second tier cities with relatively few carryout chains and sit-down restaurants.

The need for convenience has driven the changes in consumer preferences. Hectic lifestyles with less time available to prepare food boost the demand for ready prepared chilled or frozen meals. The established markets of the United Kingdom, United States and Japan have accepted ready prepared meals as complex meal solutions.

Europe is one of the largest leading markets for chilled and frozen food. The demand from European Union consumption, including United Kingdom, increased from US$ 28.85 billion in 1995 to US$ 35.06 billion in 1999. This estimate is based on a 5% annual growth rate using the actual figures (NTMP II, 2002).

Table 1 1999 World Consumption of Frozen Food

Country	US $ (Billion)
European Union	35.06*
United States	40.59
Japan	9.05**
Others	6.5
Total	91.2

Note:

The European Union consumption includes United Kingdom consumption of US$ 7.5 billion in 1995.

*Estimate is based on 5% annual growth rate using the actual figure in 1995 which is US$ 28.85 billion

**Estimate is based on 5% annual growth rate using the actual figure in 1998 which is US$ 8.62 billion

The U.K chilled food market showed strong growth in 1999. Based on UK retail chilled sales, ready prepared meals recorded the highest ranking among the chilled foods.

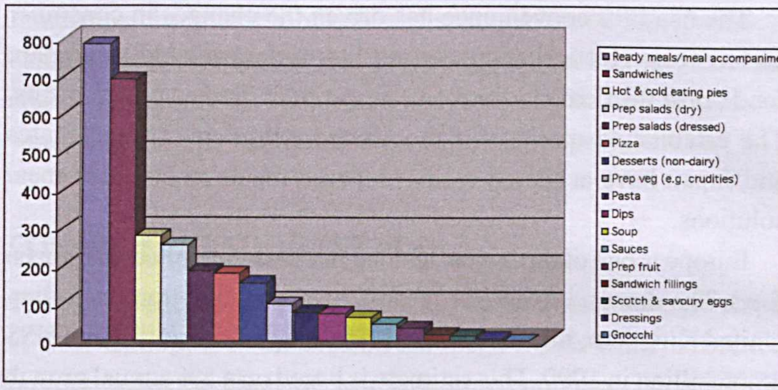


Figure 1 The 1999 UK Chilled Food Market

Note: 1999 Total estimated retail value = £ 2,992 million
Source: UK Chilled Food Organisation

United States job growth and the increase of women in the work force has spurred the movement toward ready prepared frozen food. Based on the USA retail frozen food dollar sales graph, ready prepared food was the fastest growing product compared to other product groups.

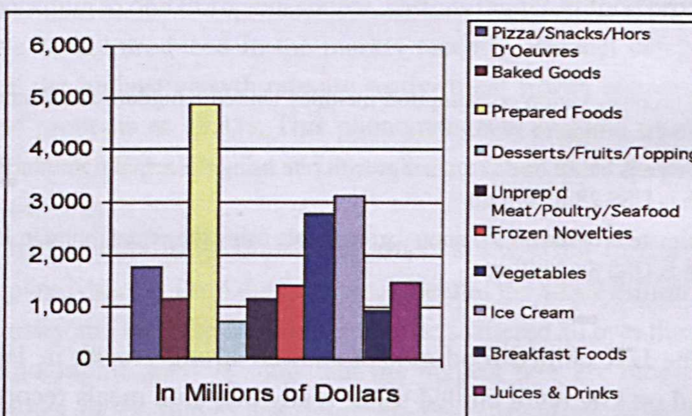


Figure 2 USA Retail Frozen Food in Dollar Sales

Source: Anon (1995) Quick Frozen Foods International, January 1995

Total sales of frozen food in Japan recorded 2.2 million metric tons in 1998, valued at approximately 861 billion Yen. Prepared food is the core segment of the market, which accounted for more than half of the industry sales (NTMP II, 2002)

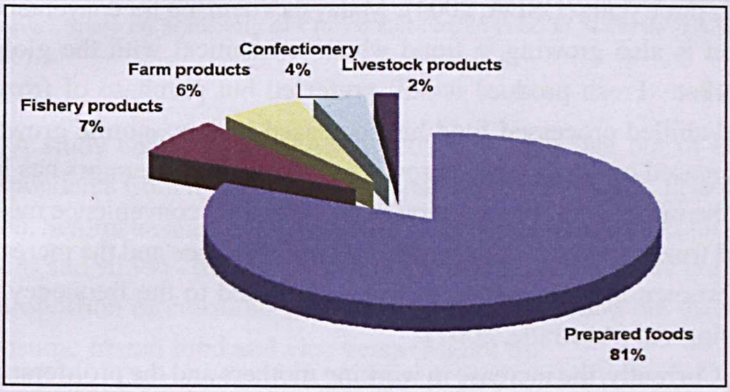


Figure 3 Production Volume by Categories (1998)

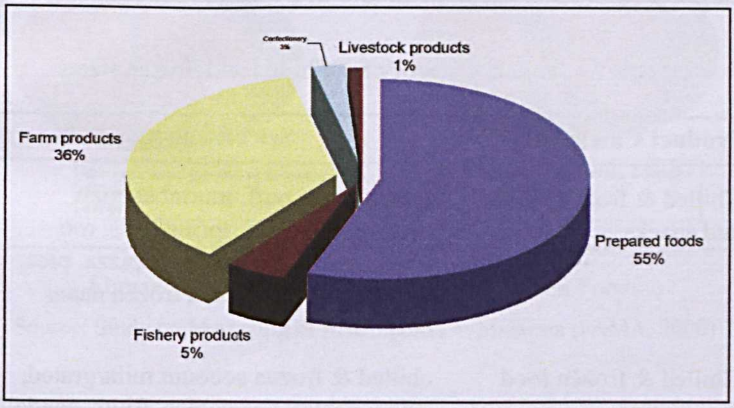


Figure 4 Consumption Volume by Categories (1998)

Source: Japan Frozen Food Association

THE LOCAL SCENE

Malaysia has a large retail food and beverage sector which was worth US$ 12.6 billion in 2003 where the food service sector is valued at US$ 3.813 billion with expected growth of 5 – 15% in the next three years (USDA, 2004). Malaysia's demand for convenience food is also growing, a trend which is identical with the global market. Fresh produce is still preferred but purchase of frozen and chilled processed food has increased with economic growth. Increased ownership of microwave ovens and refrigerators has led to the increase in consumption of pre-prepared convenience meals and frozen food products while growing affluence and the increase in women in the workforce have contributed to the frequency of dining out (Austrade, 2007).

Currently, the increase in working mothers and the proliferation of the busy lifestyles of urban citizens have led to accelerated demand for convenience food annually. Table 2 shows product categories and food items available in Malaysia presently.

Table 2 Product Category for Chilled and Frozen Items

Product Category	**Selected Items**
Chilled & frozen meals and snacks	frozen curry puff, murtabak, pau, mantau, dim sam, spring rolls, roti pratha, roti canai, samosa, pizza, pies, chilled nasi lemak and frozen naan/ chapatti.
Chilled & frozen food ingredients	chilled & frozen coconut milk/grated, spices pastes, vegetables, fruits, cendol/ cincau, taufu, noodles and Japanese ingredients.

Chilled & frozen meat and seafood	chilled & frozen burgers, sausages, nuggets, seafood, meat cuts, chicken, satay/kebab, TV dinner/lunch meal packs, Japanese type meat, marinated meat and cold cuts/dairy type of foods

Source : Study on Marketing of Chilled and Frozen Food in Malaysia (FAMA, 2000).

A study conducted by FAMA (2000) showed that out of 800 respondents from five (5) major urban areas (Klang Valley, Penang, Ipoh, Seremban and Johor Bahru), 97% of consumers prefer chilled foods and 90.99% frozen foods (Figure 5). Conversely, there is also a proportion of consumers who consume chilled food but do not consume frozen food and vice versa (Figure 6).

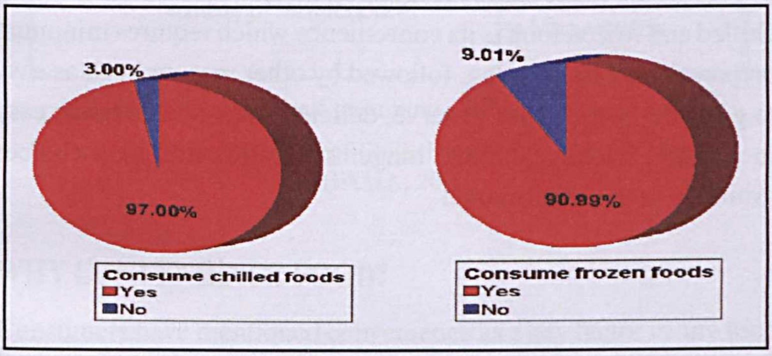


Figure 5 Consumption of Chilled & Frozen Foods
Source: Study on Marketing of Frozen Food in Malaysia (FAMA, 2000)

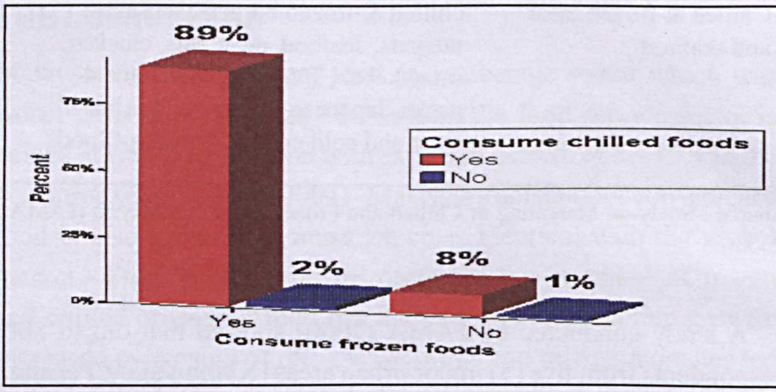


Figure 6 Cross Tabulation Between Consumption of Chilled & Frozen Foods

Source: Study on Marketing of Frozen Food in Malaysia, (FAMA, 2000)

According to the survey (Figure 7), the major reason for buying chilled and frozen food is its convenience which requires minimum preparation prior to eating, followed by other reasons such as easy to get, time saving, easy to serve, delicious, reasonable price, easy to prepare, healthy product, longer shelf life and many choices available in the local market.

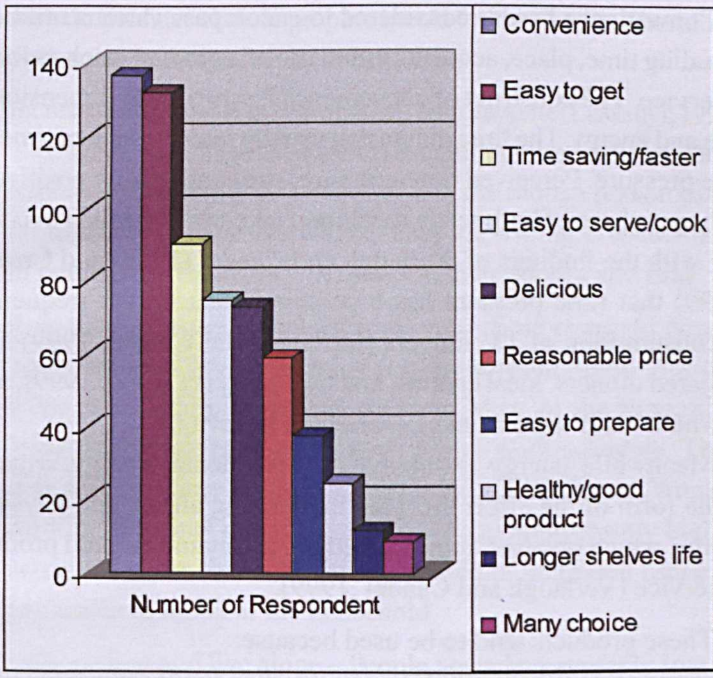


Figure 7 Reasons for Consuming Chilled & Frozen Foods
Source: Study on Marketing of Chilled and Frozen Food in Malaysia, (FAMA, 2000)

WHY CONVENIENCE FOOD?

Consumers have mentioned convenience as a key factor in any food choice .The demand for convenience has led to these prepared meals being adapted for the rapidly growing 'home meal replacement' sector (Drewnowski, 2002). 'Convenience' indicates that they satisfy a consumer need: to speed up or even avoid preparation of meals altogether. Prepared foods therefore are at a premium among professional women, singles, and people with little cooking experience or sufficient time (Martine et al., 2003)

Convenience here is considered to encompass various utilities, including time, place, acquisition and use of a product, such as food, or service. The construct of convenience has two main dimensions: time and energy. The time dimension usually refers to lack of time or time pressure. Perceived time pressures are contributing positively to the purchase of both ready meals and take-away meals. This is in line with the findings of Verlaugh and Candel (1999) and Cronin (1999) that time pressure has a positive effect on the frequency of consumption of TV dinners (Verlaugh and Candel, 1999) and prepared dinners, meal centres, and take-aways (Cronin, 1999), any of which leads to convenience-oriented behaviour.

Meanwhile energy is subdivided into mental energy, usually in the form of the effort involved in planning ahead, and physical energy, which involves doing something to obtain a desired product or service (Verlaugh and Candel ,1999).

These products tend to be used because:

- Time costs (Sherer, 2004) - convenience foods reduce the time taken to prepare meals significantly
- Variety- due to packaging techniques such as canning, freezing and chilling, food is available all the time of the year (Wikipedia, 2005). Additionally, a wide variety of convenience foods can be found in the market. It is a psychological effect that people love to have a variety of choices. With the increase of convenience foods, people are able to produce different menus and recipes. This is especially important for those who lack time and skills in cooking.
- Women In The Workforce - Increasing numbers of women in the workforce, changing family structures and lifestyles have all had an impact on eating habits. Today more than 15 million women are in employment. Since the women are now working,

they do not have time to prepare meals for the family. Therefore, convenience foods are the substitutes.

- Increased income – People are getting more income (Lassanyi, 1992) and there is an increased trend of dual income families. Both parents are working. It is believed that the more a person earns the higher their expenses will be. They are willing to spend more in purchasing foods that can save on their energy and time.
- Role overload and perceived pressure – Role overload occurs when females have two roles to play in their lives. Besides being the mother, they work as well. Most of the time, they bring their work back and have a busier work schedule. They will not have time to prepare meals especially dinner. Women working full-time outside the home report significantly higher perceived stress that is positively related to increased usage of convenience foods in the household.
- Independent and live alone – People nowadays prefer to live by themselves or not stay with parents. People living in smaller households are less likely to cook for themselves, leading to an increase in consumption of ready meals.
- Negative attitude towards cooking – people with a negative attitude towards cooking feel that routine cooking is an unnecessary task (Drewnowski, 2002). Convenience foods are a better substitute for that task. In addition, women working full-time in the home are significantly more positive about food preparation than women in the workforce. Working women with a positive attitude to food preparation and cooking use significantly less prepared dinners than women with a negative attitude towards cooking
- Social influence – we are easily influenced by people around us. Peer pressure is a significant influencer. We tend to behave

like others whereby they are now leaning towards an easy, fast and convenient method in producing foods.

EVOLUTION OF TECHNOLOGIES IN CONSONANCE WITH DEMAND

Several well-established traditional processing options are available for preservation of foods such as thermal processing and freezing. These technologies tend to degrade food quality to a certain extent and consume a great amount of energy.

Major motivators determining trends of development of new, emerging and future technologies are the following: demands of consumers due to their changing lifestyles and expectations for fresher and more natural foods which are less severely processed and/or contain less or no preservatives; nutritionally more advantageous foods; safer foods and foods convenient to handle and/or ready for consumption.

These requirements motivated the introduction of less severe or 'minimal processing' technologies such as controlled storage of fruits and vegetables, and modified packaging of foods or the development of extended shelf-life refrigerated foods such as sous vide cooked products. These requirements also resulted in the growing interest of nonthermal methods of food preservation such as ionizing radiation treatments, high hydrostatic pressure treatment and high voltage electric field pulses (Farkas, 2000).

Preservation Technologies Available for Convenience Food Products

Preservation technologies in the food processing industry are extremely important to extend shelf life of food products. Various techniques used are described below:
(Fellows, 2000; Smith, 2003; Toledo, 2001)

Heat Processing

When heat is used to preserve food, the heating process serves to reduce the concentration of microorganism in the food. In addition it may also inactivate enzyme presence. Basically the heating operation forms only part of the total preservation process which includes the addition of chemical preservatives and suitable packaging of the product or storage at reduced temperatures.

Evaporation

Evaporation is the partial removal of water from liquid foods by boiling. Separation is achieved by exploiting the difference in volatility between water and solutes.

Dehydration

The terms food dehydration or food drying is defined as the application of heat under controlled conditions to remove the majority of the water normally present in a food by evaporation. These exclude other alternative unit operations of water or moisture removal from food e.g. filtration & membrane concentration, centrifugation, solid-liquid extraction, expression and evaporation, as these methods normally remove much less water than dehydration.

Chilling

Chilling is the unit operation in which the temperature of a food is reduced to between –1°C and 8°C. Normally, it is used to reduce the rate of biochemical and microbiological changes and to extend the shelf life of fresh and processed food. It causes minimal changes to the sensory characteristics and nutritional properties of foods, and as a result, chilled foods are perceived by consumers as being healthy and fresh.

The successful supply of chilled food to the consumer depends heavily on sophisticated distribution systems which include chill stores, refrigerated transport and chilled retail display cabinets. In particular, low acid chilled foods, which are susceptible to contamination by pathogenic bacteria, for example fresh and precooked meals and pizzas and unbaked dough, must be prepared and packaged under strict hygienic conditions.

Foods are grouped into three categories according to the storage temperature as follows:

a. –1°C to +1°C for fresh fish, meats, sausages and ground meats, smoked meats and fish.
b. 0°C to +5°C for pasteurized canned meat, milk, cream and yogurt, prepared salads, sandwiches, baked goods, pasta, pizzas, unbaked dough and pastry.
c. 0°C to +8°C for fully cooked meats and fish pies, cooked or uncooked cured meats, butter, margarine, hard cheese and soft fruits.

Freezing

Freezing is the unit operation in which the temperature of food is reduced below freezing point, and a proportion of the water content undergoes a change in state to form ice crystals. The freezing time may be defined as that time during which the majority of the ice is formed in the body. Thus the International Institute of Refrigeration defines the 'nominal freezing time' to be the time elapsing from the instant the surface of a body reaches 0°C to the instant the thermal center reaches a temperature 10°C colder than the temperature of initial ice formation at that point.

The immobilization of water to ice and the resulting concentration of dissolved solutes in unfrozen water lower the water activity of the food. Preservation is achieved by a combination of low temperatures, reduced water activity and, in some foods, pre-treatment by blanching. There are only small changes in nutritional or sensory qualities when correct freezing and storage procedures are followed. The major groups of commercially frozen foods are as follows:

a. Fruits – Strawberries, raspberries, blackcurrant either whole, pureed or juice concentrates.
b. Vegetables – Peas, green beans, sweet corn, spinach, sprouts and potatoes.
c. Fish Fillets and Seafood – Cod, plaice, shrimps, crab meat including fish fingers, fish cakes or prepared dishes with an accompanying sauce.
d. Meats – Beef, lamb and poultry as carcasses, boxed joints or cubes and meat products such as sausages, beef burgers and reformed steaks.
e. Baked Goods – Bread, cakes, fruit and meat pies.
f. Prepared Foods – Pizzas, desserts, ice cream, complete meals and cook-freeze dishes.

Irradiation

Ionizing radiation is used to preserve food by destruction of microorganisms or inhibition of biochemical changes. Most of the irradiation processes suggested for foods can be classified under five headings:

a. *Radappertization* – in which a 'commercially sterile' product is produced.

b. *Radicidation* – in which the treatment is intended to destroy organisms of public health significance e.g. salmonella.

c. *Radurisation* – in which the treatment is aimed simply at the prolongation of storage life by a general reduction in the level of vegetative bacteria.

d. *Radiation Disinfestation* – where the targets are insect pests.

e. *Sprout inhibition* - in stored vegetables and growth inhibition in mushrooms.

Emerging Technologies

Agricultural production is becoming increasingly knowledge-based and science intensive. New strategic research areas have emerged and been developed with profound effects on the capacity to produce food and manage natural resources and the environment. Today consumers demand convenient and innovative fresh food, including new minimal processed products. Hence in order to meet consumers' expectations in the twenty first century, the food industry will utilize novel technologies whose purposes are twofold: to provide new quality attributes demanded by consumers and to ensure the expected assurance of food safety. Beyond the traditional food preservation methods of thermal processing, freezing, chilling, dehydration, evaporation and heating, new methods of processing and packaging have continued to emerge which can extend the shelf life and freshness of perishable foods to a new level. Some of the relevant technologies are described below:
(Da-Wen, 2005; Smith and Hui, 2004)

Ultra-High Pressure Hydrostatic Processing

At pressures of 50,000 to 120,000 psi, vegetative cells of spoilage organisms and pathogens can be destroyed with very little heating of the product. It is speculated that the mechanism of vegetative cell inactivation is through the rupture of the cell wall during pressure release. With the addition of mild heating plus high pressure, some more fragile bacterial spores can also be inactivated. The ultra-high pressure process was first commercialized in Japan where fruit products, such as jellies and jams, are being treated to extend product shelf life. This process can also be extended to heat sensitive fruits and vegetables. Future applications are likely to include liquid and semi-solid food products, for which rigid texture is a less important attribute and little or no heat for processing is desirable.

Ohmic Processing

Electric current applied directly to a conductive food allows for rapid heating of the food product. The heat generated destroys microorganisms in a manner similar to classical thermal processing. Ohmic processing has found applications in Europe, as well as in the United States. Future applications such as for aseptic food products are likely to take advantage of the unique characteristic of a process that involves both the uniform heating of particles and the suspension of fluid, together with the lack of a traditional heat transfer surface. In the future, formulated foods could be heat-treated by having liquids and suspended solids heated in different process streams and combined later. Different processing technologies may be used to optimize quality properties of the final product.

High-Intensity Light Pulses

Very intense white light (20,000 times the strength of sunlight on earth) can be pulsed at a duration of between 10^{-6} and 10^{-1} cycles per second, which results in the decontamination of food surfaces. Higher levels of energy have been shown to inactive bacterial spores as well as vegetative cells. Pulsed light may destroy microbes through both rapid surface heating, with no real cooking of the product, and a photochemical mechanism. Future surface treatment of foods and package material decontamination applications are anticipated using pulsed light technology.

High Electric Field Pulses

Electric pulses with field strength of 10 to 20 KV per centimeter have been shown to disrupt and rupture cell membranes. The pulsing creates an uneven distribution of the electrical charge across the cell's membrane, which leads to microbial inactivation. Although the process generates little heat, it is likely that it may find commercial applications in conjunction with mild heating. Future applications may include pasteurizing fruit products and alcoholic beverage products.

Radio-Frequency (RF) Heating

Food material is placed in an electrical field consisting of pulses of radio waves. This generates heat throughout by a rapid reversal of the poultry of molecules. RF has both current and future as well as for comminuted meat processing product. Other potential applications include reduction of salmonella in eggs and destroying harmful bacteria in fresh fruit juices.

Microwave Processing

A well-accepted technology for heating and thawing for the past 20 years, microwave processing has yet to have wide commercial application. The lack of uniformity of heating has been a significant technical hurdle. However, because of its properties, the process has significant potential as a technology and may be used in combination with other methods. Its use in many food-processing steps, such as blanching, baking and pasteurization, is projected for the future.

Thermo-Sonication

The combination of ultrasound and heat at moderate temperature can cause enhanced inactivation of microorganisms. This may be particularly useful for pasteurization of certain beverages where a reduced temperature is desirable. Ultrasound has potential application for emulsified foods, especially where a product's rheological qualities can be improved by ultrasound treatment.

Modified Atmosphere Packaging (MAP) and Active Packaging

Controlled atmosphere storage and preservation of package food products is a widely utilized technology for fresh foods, prepared foods and baked products. The utilization of inert gases, reactive gases or vacuum can allow for unique applications that control microorganisms as well as maintain product color and freshness. Extensive continued use of MAP in food preservation is anticipated in the future.

Packaging material can have functions other than its traditional barrier properties for oxygen control, moisture control and light restriction and against insect infestation. For example, active packaging material acts not only as a barrier to oxygen absorbers and scavengers. This active role reduces destructive chemical reactions in oxygen-sensitive products and can also help restrict the growth of oxygen-requiring microbes. The shelf life of many different product types could be increased under reduced-oxygen conditions.

TYPES OF CONVENIENCE FOODS

Convenience food usage can be in the following forms (Martine et al., 2003):

- Prepared dinners
- Meal centres (main part of meal but not complete meal),
- Prepared food items to assist meal preparation, desserts, home deliveries, retailer "food to go" foods (manufactured cooked foods, heated at retail outlet, ready to eat),
- Takeaways and restaurant meals

These different types of convenience foods have been the subject of product development in the Faculty of Food Science and Technology for quite some time now. Emphasis in applied research was focused more on freezing, cook-chill and sous vide technologies.

CONVENIENCE FOODS RESEARCHES IN UPM

A. FREEZING

Storage and Freezing Aspects of Precooked Frozen *Nasi Lemak*

Precooked frozen *Nasi Lemak* was developed in response to the increasing demand for convenience foods by consumers who want to enjoy the authentic flavours of Malaysian Food and the appeal of home cooked food. The preparation of this precooked dish was done with ease. Knowledge of the freezing temperature profile of each complementing dish in the *Nasi Lemak* was of major importance to produce a high quality end product. Such information is necessary to detect changes in quality characteristics and the microstructure of precooked frozen *Nasi Lemak*. The precooked *Nasi Lemak* dishes were then subjected to textural tests using compression test, microbiological tests and sensory evaluation. The samples of *Nasi Lemak* were left in frozen storage for six months and tested every two months. The samples were thawed using three different methods and reheated with microwave before consumption or testing. It was found that physical and microbial changes took place during storage but at a low rate within the sensory acceptability and safety consumption levels (Ibrahim et al., 2004; Ibrahim et al.,2003).

Effects of Freezing, Storage and Reheating of *Nasi Beriani*

Frozen *Nasi Beriani* was developed in response to the increasing demand for convenience foods by consumers. Freezing is an excellent and established means of preservation because it can retain food at high quality. *Nasi beriani* was prepared in accordance to a recipe from a person experienced in making *Nasi Beriani*.The cooked *Nasi Beriani* was packed in polypropylene container and frozen in the blast freezer at medium temperature of -33 °C until the thermal point of the sample reached -18 °C. The frozen *Nasi Beriani* was kept in storage for two weeks. Microwave oven was used to reheat the sample before sensory evaluation was done. No freezer burn, discolouration and freeze cracking were observed upon frozen storage, but moderate frost accumulation within the packages was noticed upon freezing. Sensory evaluation was carried out after two weeks of storage to compare quality criteria levels between freshly cooked and reheated frozen *Nasi Beriani*. The quality criteria evaluated were colour, aroma, taste and texture. The results indicated that for the colour attribute, there was no significant difference detected at α=0.05. However, there were significant differences detected at α=0.05 for aroma, taste and texture attributes. Although the panelists prefer the freshly cooked *Nasi Beriani* rather than the reheated frozen rice, the reheated frozen *Nasi Beriani* was acceptable and comparable with the freshly prepared product as shown by sensory panels Figure 8. (Wan Othman et al., 2004)

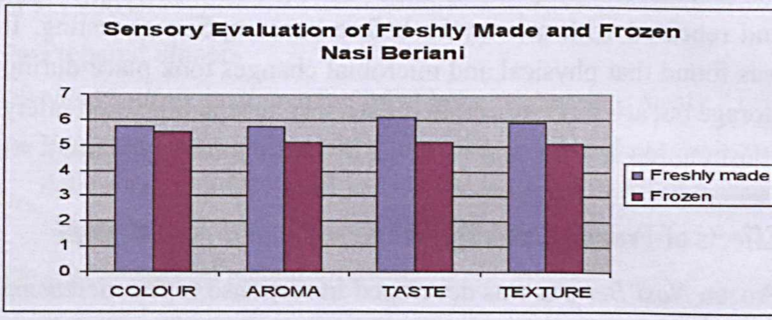


Figure 8 Sensory mean scores of freshly cooked *Nasi Beriani* and reheated frozen *Nasi Beriani*

Effects of Freezing, Storage and Reheating on *Dalcah*

Dalcah is an Indian delicacy, a spicy dish made with pigeon pea dhal (*Cajanus cajan* (L.) Millspaugh) or other pulses, onions and various seasonings. Samples were packaged in a polypropylene packaging container and frozen in air blast freezer at medium temperature of -25°C until it reached the initial temperature of -20.4°C. The freezing time for *Dalcah* is 1 hour and 50 minutes and the freezing point is between -3.3°C and -3.4°C measured using data logger. No discolouration and freeze-cracking was observed upon freezing but there was moderate occurrence of frost accumulation within the packages. Samples were then stored in a chest freezer (-18°C) for 2 weeks. After two weeks storage, samples were reheated for 6 minutes in a microwave oven to a core temperature of 70°C. The reheated samples were then compared with the freshly cooked sample by sensory evaluation to determine differences in terms of color, aroma, taste and texture using hedonic scale. Results show that there is no significant ($p>0.05$) difference between the freshly cooked and frozen *Dalcah* after 2 weeks storage (Figure 9 and Figure 10). Results also indicate that most panelists prefer freshly cooked *Dalcah* as compared to reheated frozen *Dalcah* (Wan Othman et al., 2004). However, frozen *Dalcah* was still acceptable by the panelists as indicated by average mean scores greater than 5 (like slightly) (Table 2) (Azimah, 2004).

Table 2 Comparison between freshly cooked (control) and air-blast frozen (non- stored) *Dalcah*.

Property	Freshly cooked *Dalcah*	Air-blast frozen (non-stored) *Dalcah*
Physical Appearance:		
Discoloration	-	No changes from control
Freeze-cracking	-	No changes from control
In-packaged frost formation	-	Moderate changes from control

Figure 9 Physical appearance of freshly cooked *Dalcah*

Figure 10 Physical appearance of reheated frozen *Dalcah* (2 weeks)

Effects of Freezing, Storage and Reheating on *Ayam Kurma*

This study was conducted to determine the effect of freezing, storage and reheating of *Ayam Kurma*. *Ayam Kurma* was prepared by cooking chicken meat pieces with spice ingredients in appropriate amounts. Samples were packaged in polypropylene (PP) packaging for good heat resistance and frozen in the blast freezer at medium temperature of -33°C until the thermal point of the sample was -18°C. The freezing time obtained was 2 hours 43 minutes. Samples were then removed and placed in a box freezer at -18°C for 4 weeks. After 2 weeks storage, samples were reheated in microwave oven at 72°C and tested for sensory evaluation. Sensory test was carried out to compare quality criteria between freshly cooked and frozen *Ayam Kurma*. The quality criteria evaluated were colour, aroma, texture, juiciness, taste and tenderness using hedonic scale. The results obtained showed that there was no significant ($P>0.05$) difference between freshly cooked and frozen *Ayam Kurma* in terms of colour, aroma, texture, juiciness and taste. However, frozen *Ayam Kurma* showed significant ($P<0.05$) difference in terms of tenderness of chicken meat. This study indicated that on overall acceptability, the panelists prefer freshly cooked *Ayam Kurma* to the frozen one. Nevertheless, frozen *Ayam Kurma* was still acceptable by panelists as the average mean scores were greater than 5 (on a 1-7 scale) (Wan Othman, 2004).

Freezing, Reheating and Sensory Evaluation of Mutton Soup

The soup was prepared by boiling Australian mutton with spices such as cinnamon sticks and cooked until the meat became tender. After being chilled, the samples were air-blast frozen to core temperature of -21°C, removed and placed in a chest freezer (-18°C) for 2 weeks. From the freezing curve obtained, the soup freezes at -2°C after 2hours. Some samples were taken out immediately after air-blast freezing to determine best reheating time and the effects of freezing. The samples were reheated using a microwave oven. The differences in appearance and aroma of the soup as well as tenderness of the meat between the fresh samples and the frozen-reheated samples (Figure 11 and Figure 12) were closely observed. However, there were no significant ($P>0.05$) differences in these attributes and overall flavor among the samples as seen from the results of the sensory evaluation. Moderate occurrences of frost accumulation within packages, freezing loss (1.08%) and reheating loss (8.65%) were noticed upon freezing. Freezing resulted in no significant ($P>0.05$) changes in the aroma, appearance, flavor and tenderness of the meat. Sensory evaluation of frozen mutton soup revealed that appearance, aroma and natural flavour differed slightly from the fresh sample. Other parameters such as overall flavour, freshness quality and juiciness of the meat remained undifferentiated by the taste panelists. Overall, the frozen soup after reheating was accepted by the panelists (Ishak, 2004).

Figure 11 Frozen samples before reheating

Figure 12 Sample after reheating in microwave oven.

Effects of Freezing and Reheating on *Sata*

Sata has a unique texture and the taste of fish. Ingredients that are used in the *Sata* formulation are essential to the taste of the *Sata* as introduction to the new consumer. In order to develop good *Sata* and the best way to store it, experimental design of study was carried out. *Sata* was cooked using an oven, stored in a freezer and reheated using microwave for about 2 minutes. The freezing behavior and the temperature changes of *Sata* in the air-blast freezer were recorded and the reheating characteristics of *Sata* studied. Texture profile analysis of samples was evaluated after reheating the *Sata* using different methods. Thiobarbituric Acid Value (TBA) test was also done to examine the rancidity of the *Sata* after frozen storage and reheating. To test the acceptance of the frozen *Sata*, a sensory test was developed to compare the degree of acceptance, and the difference between fresh and frozen *Sata*. There was significant difference between frozen *Sata* (Figure 13) and fresh *Sata* in terms of the attribute of spiciness and overall acceptability (Hazaifah, 2004).

Figure 13 Sample of Frozen *Sata*

Effect of Freezing Methods and Reheating on Mashed Pumpkin

The effects of freezing methods on cooked mashed pumpkin were investigated with two different methods namely slow and quick freezing. The changes in colour, pH, texture, moisture content and sensory evaluation were tested. The analyses were done before and after two weeks of storage. Mashed pumpkin was prepared by cooking the pumpkin using pressure cooker and mashed using mincers. After being packaged, the sample was subjected to air-blast freezer until core temperature of the sample reached -21°C ± 2°C. The sample was then immediately removed and placed in a vertical box freezer at -18°C ± 2°C for two weeks. After freezing, some samples were taken out to determine the best reheating method and effects of freezing. Determination of the best reheating method was based on optimum reheating time and sensory evaluation. The microwave oven reheated the sample fastest compared to steamer. The Microwave reheated sample was scored highest in overall quality attributes by panelists. No discolouration was observed in the mashed pumpkin after air-blast freezing and slow freezing. Moderate accumulation of frost occurred within the containers in slow freezing method. Samples subjected to air-blast freezing and slow freezing, and subsequently reheated using microwave oven were compared with freshly cooked samples for pH, moisture content and instrument measurement. There were significant changes in pH after 2 weeks storage. Freezing resulted in significant ($p<0.05$) difference in terms of moistness and overall quality. Sensory evaluation of frozen mashed pumpkin indicated that in terms of aroma, sweetness and colour there was no significant ($P>0.05$) difference between quick and slow freezing. There was significant ($P<0.05$) difference in texture in both freezing methods. Therefore, the quick freezing method and reheating of frozen mashed pumpkin using microwave oven were best to retain the quality characteristics of the mashed pumpkin (Salleh, 2004).

Freezing Characteristic and Storage Stability of Frozen Packed Toastable Chapatti

Chapatti, unleavened baked flat bread is a popular traditional food in the Indian community. Mixing flour with water to make dough, adding salt, flattening or shaping the dough and then heating it makes unleavened bread. It is normally prepared and consumed fresh in households and restaurants. The major problem with chapatti is its short shelf stability, which includes an increase in rancidity, mold growth and production of off-flavour. The demand for ready-to-eat food is increasing; therefore there is a definite need to preserve chapatti for long-term storage. The most common method for long-term preservation of food is freezing. The objective of the study was to produce a convenient chapatti that is prepared, prepacked and ready for consumption after minimal preparation. The chapattis were prepared from whole-wheat flour, fat, salt and water. Four different types of packaging materials namely polypropylene (PP) flexible film, PP rigid containers, aluminum laminated and high-density polyethylene (HDPE) films were used (Figure 14). Unpacked chapattis were frozen using an air-blast freezer until it reached -15°C at the thermal center. Freezing time was determined for different layer and thickness of chapattis. Freezing time was the time taken to reduce the temperature of the chapatti at the thermal center from 15°C to -15°C. The frozen chapattis were stored at -20°C for 12 weeks. At two weeks intervals, moisture content, lipid oxidation and microbial counts were determined. At the end of storage, PP flexible film was found to be an effective means to protect chapatti from dehydration and lipid oxidation. Bacterial counts were low in packed frozen samples. Samples packed in PP flexible films had the lowest moisture loss and TBA values. The experimental determination of freezing time was influenced by size and dimension of product, air temperature and location of thermal center while theoretical determination was influenced by physical parameters and assumptions made in the freezing time equation. The sensory evaluation results showed that frozen toasted chapatti did not have the characteristics of freshly toasted chapatti (Figure 15) (Usha Malini, 1996).

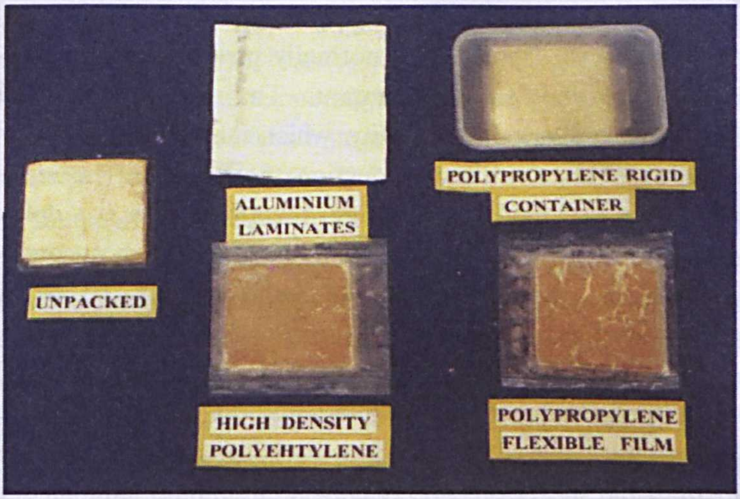


Figure 14 Chapattis packed in different packaging material

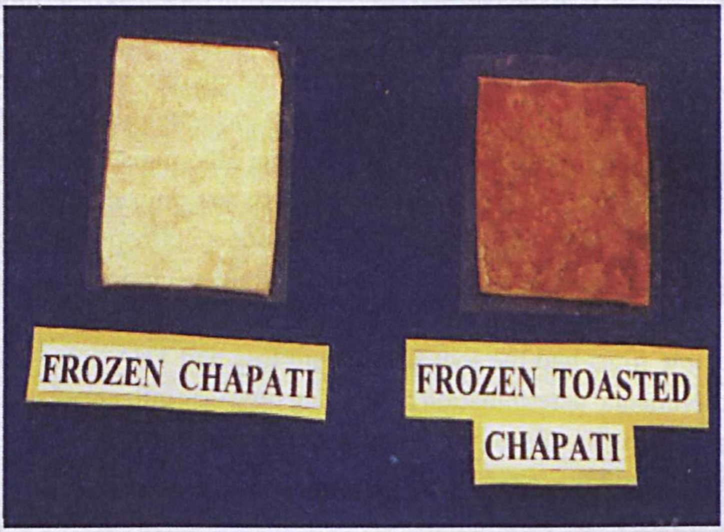


Figure 15 Fresh and frozen toasted chapattis

Effect of Freezing, Storage and Thawing on Pure Pineapple Juice

Pineapple juice, as a non-citrus fruit juice is a food product of attractive appearance; pleasing aroma; good flavour and contains a fair source of vitamin A and C. Most of the pineapple juices in the current market are preserved by addition of chemical preservative. The demand for fruit juices with original characteristics of fresh fruits and free from chemical additives is increasing, therefore there is a definite need to preserve fruit juices with other preservation methods rather than chemical preservation. A method of preservation to preserve the quality of fruit juice is by freezing. The objective of this study was to produce pure pineapple juice in frozen form, without adding any chemical preservative for the purpose of preservation. The pure pineapple juice was prepared from ripe pineapples (*Ananas Comosus* var. *Johor*). 230ml of pure pineapple juice was packed into Polypropylene (PP) pack of 3"x12" size and 0.04mm thickness. The packed pure pineapple juice was frozen using an air-blast freezer until it reached -21^{0}C at the thermal center (Figure 16). Freezing time and freezing point of the juice were determined. Freezing time of 90 minutes was required to reduce the temperature of the pure pineapple juice from its initial temperature of 24^{0}C to -21^{0}C at the thermal center. Freezing point was determined as -1.9^{0}C. The frozen pure pineapple juice was stored at -18$\pm$2 ^{0}C for 2 weeks. The physical and chemical changes after freezing, storage and thawing were investigated. Parameters studied included pH, total soluble solid, color (Hunter 'L', 'a' and 'b'), viscosity and microbial count. Freezing and thawing losses were also measured. Sensory evaluation test using 10-points hedonic scale was used to evaluate the juice. The results showed that freezing did not affect the pH and total soluble solids but increased the Hunter 'L', 'b' value and viscosity, and decreased

Hunter'-a' value. There were no drastic changes due to frozen storage. No significant change was observed in pH. Frozen storage and thawing losses were observed. Reduction of microbial counts due to freezing slightly increased during the thawing process. The sensory evaluation results showed that there was no significant ($p<0.05$) difference between freshly prepared and frozen-thawed pure pineapple juice at 5^0C and 28^0C (Tang, 2004).

Figure 16 Physical appearance of fresh and frozen pure pineapple juice

Effect of Freezing on Carambola Juice

Parameters investigated in this study were on the chemical and physical properties of the juice before and after freezing. The pH, total soluble solids (°Brix), colour ('L', 'a' and 'b'), viscosity, microbial count and thawing method of Carambola juice were determined. Sensory evaluation was conducted for juices prepared at different temperatures namely at 28°C and 5°C. Colour, sweetness, sourness, aroma, viscosity and overall acceptability were evaluated using 9-point hedonic scale in the sensory tests. The freezing time for Carambola juice was 86 minutes to reach temperature of -21.3°C and freezing point was at -1.1°C (Ng, 2004).

B. COOK-CHILL

Chilling Behaviour and Storage Stability of Cook-Chilled Vacuum Pack Soft Shell Crab

This study was conducted to determine the chilling behaviour and the effects of vacuumed pack of chili oyster sauce soft shell crab stored in chilled storage of 3°C. The vacuumed chili oyster sauce soft shell crab required 37 minutes to chill to 3°C in -3°C frozen storage. Chili oyster sauce soft shell crab was prepared based on the Rasa Malaysia recipe book and was vacuum packed, rapid chilled and stored at chill temperature (3°C) (Figure 17). The physical, chemical, microbiological and sensory analyses were carried out to evaluate the shelf life of the chili oyster sauce soft shell crab at 2 day intervals for 2 weeks of storage. There were two types of samples one that underwent the vacuum pack treatment and the other which acted as control which was cooked, heat sealed, and stored at 3°C. Overall, there was not much difference ($P>0.05$) between vacuum and non-vacuum packed samples in instrumental texture measurement, water activity, TBA and moisture content values as well as microbiological load (psychrophilic count) of chili oyster sauce soft shell crab stored in 3°C but there was significant difference ($P<0.05$) in pH value upon storage whereby both of the samples became more acidic after 14 days of storage in the chiller. Further, there was also significant difference ($P<0.05$) in mesophilic count for both samples. The vacuumed chili oyster soft shell crab was acceptable to the sensory panelists on the overall. Results demonstrated that the vacuum packed cook chill system is an effective method for producing chili oyster soft shell crab compared to the heat sealed cook chill system as the vacuum packed method enhances the shelf-life of such products, slows down the oxidative reactions via chilled temperature storage, and thus prevents rancidity and provides convenience not only at home but also to the food service system (Louton, 2006).

Figure 17 Physical appearance of vacuum packed "chili oyster sauce soft shell crab"

C. SOUS VIDE

The name *sous vide* originated from France and upon literal translation means "under empty" which is synonymous with "under vacuum" and "without air" (Leadbetter, 1989). As per *Sous Vide* Advisory Committee, *sous vide* (*Cuisine en Papillote Sous Vide)* is an interrupted catering system in which raw or par-cooked food is sealed into a vacuumised laminated plastic pouch or container, heat treated by controlled cooking, rapidly cooled and then reheated for service after a period of chilled storage (Creed, 2000).

Sous vide processing of food products allows the production of high quality foods with better than average sensory properties. It is also packaged in such a way that the food product is convenient to use. Thus, it is envisioned as a means to support the increasing growth of the foodservice sector.

Malaysian cuisine is a fusion of three major influences: Malay, Chinese and Indian (Galimpin-Johan and Abdul Rahman, 2007). Other influences are the Dutch and the Portuguese which in some parts of the country has evolved unique styles such as the *Nyonya cuisine*. A good many local dishes require time and effort to prepare and cook. A good example is *rendang* which is a popular food served during *kenduri* and special occasions. It consists of beef or chicken or turkey, eight ground ingredients for marinating and coconut which is cooked slowly for up to 4 hours. Thus, *rendang* is a natural choice for a product to be processed via sous vide (Abdul Rahman et. al., 2007).

Consumer perception of *sous vide* products is currently mixed. Rhodehamel (1992) stated that *sous vide* products are generally formulated more for sensory properties rather than its safety considerations thus receiving minimal heat treatment and its vacuum packaging favors the growth of anaeraobic microorganisms and further, adequate refrigeration must be maintained at all times to prevent outgrowth of *C. botulinum*. Betts and Gaze (1995) have advocated the use of psychrotrophic *Clostridium botulinum* as reference microorganism during the processing of *sous vide*. The authors elucidated the same reasons as Rhodehamel adding that use of vacuum packaging, chill temperatures and lack of competitors may actually favor its growth.

If milder heat treatments are given, evidence must be provided that other preservation factors or combinations thereof are operating to inhibit the growth of surviving spores (Gould 1999). Thus, a food safety design (Rybka-Rodgers 2001), whereby additional hurdles aside from pasteurization may be added to lower the amount of heat applied, is a promising scenario. Sous vide products have great potential in the food service industry to satisfy consumer demands for higher quality food service and the increasing demand for foods that require minimal preparation time, high quality, contain low levels of preservatives and are only minimally processed (Figure 18) (Khairuddin, 2005).

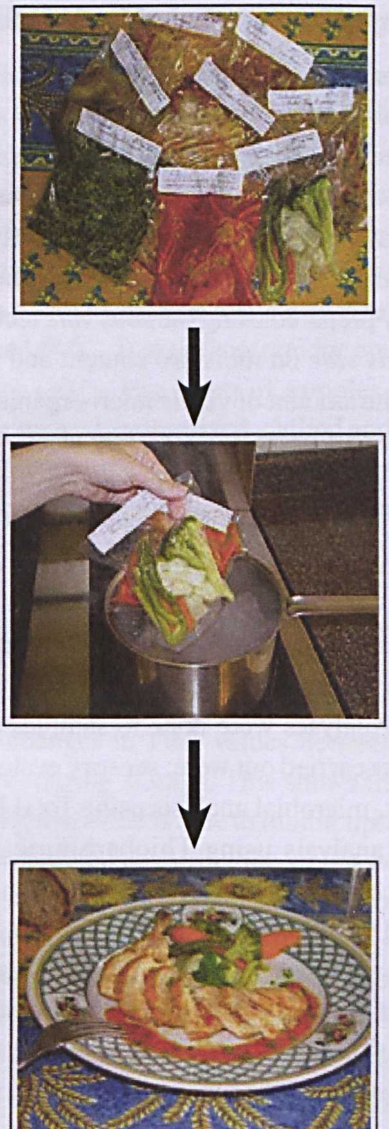


Figure 18 Examples of Sous-vide products and how they are prepared

Storage Stability of Vacuum Packed Cook-Chilled Beef Satey

From observation of the conventional way of cooking and preparing beef satey, *sous vide* (vacuum-pack cooked chill) processing method was developed for its use to offer convenience and storage stability. However, for meat products the *sous vide* method is not clearly recognized, especially for satey – a Malaysian cuisine. The objectives of this study are: to observe the shelf life or storage stability of satey prepared using the *sous vide* technique, to observe the effect of *sous vide* on moisture content and sensory attributes and to identify the amount of viable microorganisms. The *Sous vide* process consisted of preparing the raw satey which was bought from a hawker near Tasik Serdang, Selangor, grilled using oven grill, vacuum packed in a heat stable pouch (polyamide) using vacuum pack machine, pasteurizing the sealed package by dipping in water bath at 96°C for 15 minutes, rapid cooling and storage at chilling temperature (5°C). Heating profile during pasteurization was obtained with a thermocouple located in the thermal centre of the sample. Analyses were done to samples in storage for two weeks only. Tests carried out were; sensory evaluation using paired comparison test, microbial analysis using Total Plate Count (TPC) test, chemical analysis using Thiobarbituric Acid (TBA) test, approximate fat content using Soxhlet method and other minor tests such as pH and moisture content. The *sous vide* processed satey resulted in better sensory quality and storage stability compared to conventional methods. It was also significantly effective in protecting the food from microbial contamination and sensory degradation (Nor Zaki, 2005).

Effects of Sous Vide Processing on Chicken Tom Yam

This study was conducted to determine the effects of sous vide processing on chicken Tom Yam stored in chilled storage at 3^0C. The analysis carried out were on physical, chemical, microbiological and sensory attributes on the shelf life of chicken tom yam for 14 days. Chicken tom yam was prepared by frying diced chicken breast with tom yam paste and coconut milk. The cooked chicken tom yam was then vacuum packed and pasteurized until the core temperature reached 90^0C. It was then rapidly cooled and stored at chill temperature (3^0C). Two types of samples underwent full treatment (vacuum packed, pasteurized, chilled and stored at 3^0C), the sous vide sample and the other which acted as control which was cooked, packed, chilled and stored at 3^0C. The tenderness of the chicken tom yam was not significantly different (P>0.05) during storage for both the sous vide and control samples. The moisture content decreased slightly on the 12^{th} day which was significantly different (P<0.05) than from day 0 to day 9. However there were no changes in pH during storage. There were significant (P<0.05) differences in the changes in TBA values between the sous vide samples and control during storage. This shows that chicken tom yam processed using sous vide is able to inhibit lipid oxidation. No microbial growth was detected during the whole storage period of 15 days for the sous vide samples. Growth of microbes was detected after 3^{rd} day of storage for control samples. This shows that chill temperature, vacuum packaging and pasteurization can lower or even inhibit microbial growth. Significantly (P<0.05) higher scores were observed for freshly cooked chicken tom yam compared to sous vide samples in terms of colour, aroma, texture, tenderness, juiciness, freshness and overall quality except for flavour which showed no significant (P>0.05) difference. Also, there were no significant (P>0.05) differences between 1 week storage and 2 week storage for all attributes (Ho, 2005).

Storage of Vacuum Packed Cook-chilled Ginger Chicken Soup

Ginger Chicken Soup was processed using *sous vide* method and stored at 3°C for 14 days. Analysis was carried out throughout the 14 days of storage and compared with 0 day storage (as control) for freshly cooked and *sous vide* treated Ginger Chicken Soup stored at room temperature. There was only a slight increase in TBA value, microbial load (total plate count), and pH value throughout the period of storage at 3°C compared to control. Further, there was not much difference between the sample that was freshly cooked and the *sous vide* treated Ginger Chicken Soup stored at 3°C but significant differences ($p<0.05$) when compared to sous vide treated Chicken Soup stored at room temperature, which had high TBA value, microbial load and low pH value. The sous vide treated Ginger Chicken Soup stored at 3°C was acceptable by the sensorial panelists on the overall. Results demonstrated that the sous vide (cook-chill) system is an effective method of producing Ginger Chicken Soup that is microbiologically stable which enhances the shelf-life of such products, slows down the oxidative reactions via chilled temperature storage, and thus prevents rancidity and provides conveniences to the foodservice system (Marvis Lim, 2005).

Storage of Vacuum Pack Cook-chilled Fried *Kai Lan*

Fried *Kai Lan* was vacuum-packed and cooked (sous vide) at 90°C for 10 minutes. The cooked samples were stored at 3°C. The TBA values, total plate count, pH and sensory evaluation of the samples were evaluated for 2 weeks. Although sous vide treatment of fried *Kai Lan* displayed lower pH value in the samples and increased TBA values and total plate counts throughout the 2 weeks storage when compared with the control (immediately cooked fried *Kai Lan*), the results indicated that the product was still at a safe level for consumption. Microbial test showed that the microbes would not be able to survive the thermal treatment currently recommended by the sous vide industry (90°C) for the manufacture of sous vide products. Also, results indicated that the sensory quality and consumer acceptance of sous vide fried *Kai Lan* can be retained for 14 days storage. Results demonstrate that sous vide treatment was an effective method to enhance the shelf life of fried *Kai Lan* (Lee, 2005).

Storage of Vacuum Packed Cook-chilled *Maggie Goreng*

The aim of this study was to determine the physicochemical changes, microbiological quality and the sensory quality of Vacuum Packed Cook-chilled *Maggie Goreng* (Sous Vide product) for 2 weeks. The Fried noodles was immediately vacuum packed, pasteurized until core temperature reached 90°C, chilled and stored at chill temperature (3°C). Some samples (packed and chilled) were non-vacuum packed and stored at chill temperature (3°C). There were no significant ($P > 0.05$) differences for pH, moisture content and TBA value during storage of the Sous Vide (SV) samples. No significant ($P > 0.05$) differences for pH, moisture content and TBA value was observed between the sous vide samples and the freshly cooked *Maggie Goreng* but there were significant ($P < 0.05$) differences for TBA value between sous vide samples and packed and chilled samples. This shows the effectiveness of vacuum packaging in lowering lipid oxidation reactions. The Sous vide samples showed negligible microbial growth throughout the storage period. Microbial growth increased during storage for packed and chilled samples. The highest microbial numbers for sous vide samples and packed and chilled samples were 1.858 log cfu/g estimated and 5.502 log cfu/g respectively. This shows the effectiveness of pasteurization. Texture Profile analysis (TPA) shows that the sous vide samples became softer with storage and no significant ($P > 0.05$) difference between sous vide samples and freshly cooked *Maggie Goreng*. Sensory evaluation of sous vide samples revealed that taste, aroma, texture and overall acceptability decreased slightly, and there were no significant ($P > 0.05$) differences between sous vide *Maggie Goreng* and freshly cooked *Maggie Goreng* (Wong, 2005).

Effects of Sous Vide Processing on *Nasi Goreng*

The effects of sous vide processing on *Nasi Goreng* in terms of physical, chemical, microbiological and sensory aspects for 15 days storage were studied. Microbiological analysis namely TPC (total plate count) and chemical analysis including moisture content, pH value and TBA value determination were carried out every 3 days starting from day 0. Meanwhile, the physical analyses, which covered the physical appearance observation and texture measurement as well as the sensory evaluation, were carried out every 7 days. Results obtained showed that sous vide treatment resulted in reduced total plate count in comparison to the freshly prepared product from 850 Est cfu/g to <100 Est cfu/g and the microbial count in the sous vide product did not increase significantly throughout the 15 days of storage. Meanwhile, the moisture content in the sous vide product increased significantly ($p<0.05$) in comparison with the freshly prepared product from 61.12% to 63.07. However, time in chilled storage had not much of an effect on the moisture content in the sous vide product. The pH value was not affected much by sous vide treatment and during storage. TBA values increased steadily after the sous vide treatment throughout the 15 days of storage but the increment was insignificant ($p>0.05$). This trend also applied to the hardness of the rice but the hardness of the mixed vegetables added into the *Nasi Goreng* decreased after sous vide treatment and throughout the 15 days of storage. Overall, the degree of acceptability for sous vide product was still within the acceptable limit as judged by the sensory panels (Lee, 2005).

Storage of Vacuum Packed Cooked-Chilled Spaghetti and Bolognaise Meat Sauce

This study was conducted to determine the effects of chilled storage (3°C), by investigating chemical, physical, microbiological changes and sensory evaluation, and to study the effects of vacuum packaging and pasteurization on shelf life of vacuum packed cooked-chilled spaghetti and Bolognaise meat sauce for 14 days. After adding previously cooked spaghetti to commercially produced Bolognaise meat sauce, the product was vacuum packed, pasteurized until the core temperature reached 90°C, rapid cooled and stored at chill temperature (3°C). Another sample was only packed, rapid cooled and stored at chill temperature (3°C) without any treatment, which acted as control. There was no significant ($P>0.05$) difference found between the cook fresh and sous vide product for changes in moisture content in day 0 storage. The moisture content did not change significantly throughout the storage period for the sous vide product. For TBA value, there was significant ($P<0.05$) difference between the sous vide product and cook chill product (control). This showed the effectiveness of vacuum packaging and chilled storage in lowering the lipid oxidation for spaghetti and Bolognaise meat sauce. No microbial or <25 colony growth could be detected for the sous vide product from day 0 until day 14. For the cook-chilled product, the growth of microbes significantly increased after 5 days storage. This showed that samples vacuum packed and pasteurized can lower microbial growth. No significant ($P>0.05$) differences were found in appearance, odour, texture and taste for the cook fresh (control) and sous vide product after storage for 14 days (Ong, 2005).

Storage of Vacuum Packed Cook Chilled *Wantan Mee*

In this study, the storage stability of vacuum packed cook-chilled (sous vide) processed *Wantan Mee* was monitored over a storage period of 2 weeks at 3°C. The storage stability was determined in terms of changes in texture profile, sensory acceptance, Thiobarbituric Acid (TBA) value, pH and microbiological quality. Instrumental Texture Profile Analysis (TPA) was carried out on different components of the *Wantan Mee* using Texture Analyser at weekly intervals. At the same time, the TBA value and pH of the sous vide product were measured to monitor the change in rancidity and acidity. Hedonic Scale was employed to analyze changes in sensory attributes of different components in the *Wantan Mee* and overall acceptability during the storage period. In terms of microbiological quality, total plate counts of the sous vide *Wantan Mee* were determined every 3 days starting from the day of production. Total plate count at the end of the second week of storage was 4×10^4 cfu/g which indicated that the product was still safe to be consumed. Hedonic scale rating results indicated that the product significantly changed in sensory quality, acceptance and texture throughout the 2 weeks of storage. However, there was no significant change ($p>0.05$) in rancidity and acidity of the sous vide product (Yan, 2005).

Sous Vide Processing of *Rendang*

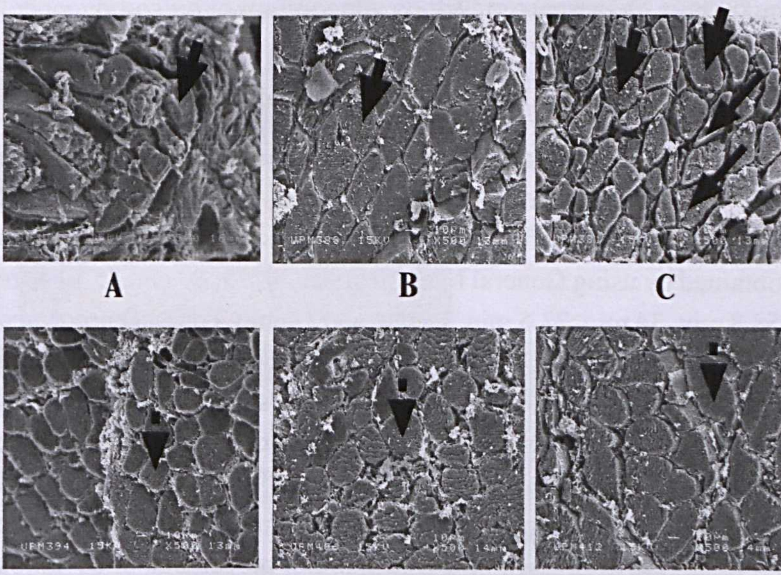
A study by Galimpin-Johan et al., (2007) encompassed product and process development, decontamination procedures to increase food safety and quality and structural changes of sous vide beef *Rendang* (Figure 20) with or without papain pretreatment. Sous vide *Rendang* may be pasteurized for 443 min at 75°C (SS70) and 88 min for 85°C (SS85) using fast heating to meet the $Pv_{90} = 10$ min guideline for pasteurization. Process-meat-formulation combinations of sous vide *Rendang* indicated that processing at 85°C/2hrs, the use of rump and formulation 1 produced better sensory properties (Galimpin-Johan et al., 2004a). Aside from pasteurization Aw is a possible controlling factor for sous vide *Rendang* but not pH. Conventionally cooked *Rendang* stored at 2°C and sous vide *Rendang* pasteurized at 70°C/100 min or 1.67 hrs and 85°C/2 hrs stored at 2° and 10°C can last for 35 days using microbiological count as its storage indicator. Applications of United Kingdom Food Standards Agency (UKFSA) guidelines would mean that the maximum shelf life allowable for conventionally cooked and SS70 will only be 10 days compared to SS85 which is 40 days.

As shown in Figure 21, Scanning Electron Microscopy (SEM) observations show that raw material, conventionally cooked, precooked and vacuum packed *Rendang* showed regular shapes in the muscle fiber. Deformation of cells show a progressive trend as time of cooking was increased from 75°C to 85°C. Fiber diameter showed $\leq$60% decrease in diameter from the raw material compared to conventionally cooked *Rendang* and sous vide processed *Rendang*. Tenderness, as measured by Texture Profile Analysis (TPA), showed a decreasing trend as the processing time was extended from 4 to 8 hrs at 75°C and 1 to 2 hrs for 85°C. Deformation of cells and shrinkage can be attributed to loss of fluid from the myofibril. The addition of 0.05% papain for beef tenderization was able to lower the amount of cooking required for sous vide *Rendang* to 90°C for 30 min. Furthermore there was no significant loss of quality in terms of texture, physicochemical and sensory attributes upon comparison with untreated sous vide *Rendang*.

Raw plant materials have high microbial load due to their origins contributing potential hazards to consumers, thus, a decontamination process is important. Organic acids were applied to plant materials (bird chili, galangal, lemon grass, ginger and turmeric) (Figure 19) at 1, 2 and 4% concentration to decrease microbial load (Galimpin-Johan etal., 2004b). Screening at 4% level showed that calcium lactate and sodium lactate were less effective compared to acetic acid and citric acid in reducing microbial load. Effectiveness of decontamination was material specific with bird chili, galangal, lemon grass and turmeric more affected by acetic acid and ginger by citric acid. Generally, acetic acid was more effective than citric acid. Additionally, optimal levels of application observed were 4% acetic acid and 2% citric acid for acid decontamination of raw plant materials. Further, decontamination at 4% acetic acid did not have any adverse effects on the sensory properties of sous vide *Rendang*.

Figure 19 Raw Materials for Sous Vide Spicy Beef Stew (Rendang) Processing

Figure 20 Final Product or Sous Vide Spicy Beef Stew *(Rendang)*



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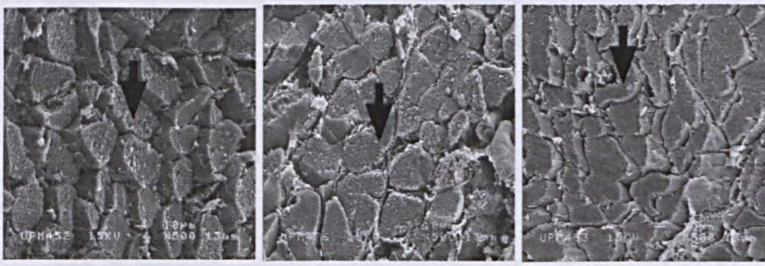

G H I

Figure 21 Muscle Fiber Changes of Sous Vide Spicy Beef Stew *(Rendang)*

A – raw material, beef rump (RM); B – conventionally cooked spicy beef stew, slow cooking for 2 hrs (CC); C – precooked, vacuum packed spicy beef stew (VP); D – SV processing 75°C/4 hrs (SV754); E – SV processing 75°C/6 hrs (SV756); F – SV processing 75°C/8 hrs (SV758); G – SV processing 85°C/1 hr (SV851); H – SV processing 85°C/1.5 hrs (SV8515); I – SV processing 85°C/2 hrs (SV852) Magnification at 500x

Preparation of Sous Vide Chicken Rice and Chicken Keel

Time-temperature profiles and process time for sous vide chicken rice and chicken keels (Figure 22) were obtained through heat penetration test. For 5 D processed chicken rice, the process times obtained by using General Method at 65, 70, 75, 80 and 85°C were 58.8 min, 34 min, 23.5 min, 18 min and 14 min. For 13 D processed chicken rice, the process times were 125.8 min, 61.8 min, 34.5 min, 24 min and 18.5 min, respectively. In slow heating (75°C) of chicken keel, the process times for 5 D and 13 D processes were 26.7 and 38.3 min whereas for fast heating (90°C), it was were 16.5 and 19.2 min, respectively. Ball's method could also be used for the computation of process time due to minor percentage of deviation from General Method (4 - 14% for all the process time computed above) (Tan et al., 2003).

Traditional cooked chicken rice (the reference) had pH 6.29 and aw 0.986 while sous vide chicken rice products, had pH 6.35 and aw 0.984, and had microbiological and chemical stability from day 0 until week 4. Generally, better aroma and flavour retention were obtained in the sous vide products compared to the traditional cooked products. Texture changed significantly ($P<0.05$) when different cooking methods or time-temperature combinations were used but not for storage duration. Chicken keels were also stable from any microbiological spoilage. TBA test showed significant ($P<0.05$) changes in rancidity although the sensory mean scores were only at the low range of 1-3. Although the preference of panelists towards the sous vide products was not significant ($P < 0.05$), sous vide products showed their benefits with better retention. of aroma and flavour, lower cook loss, and being juicier and more tender compared to traditionally cooked products (Tan, 2005; Tan et al., 2004).

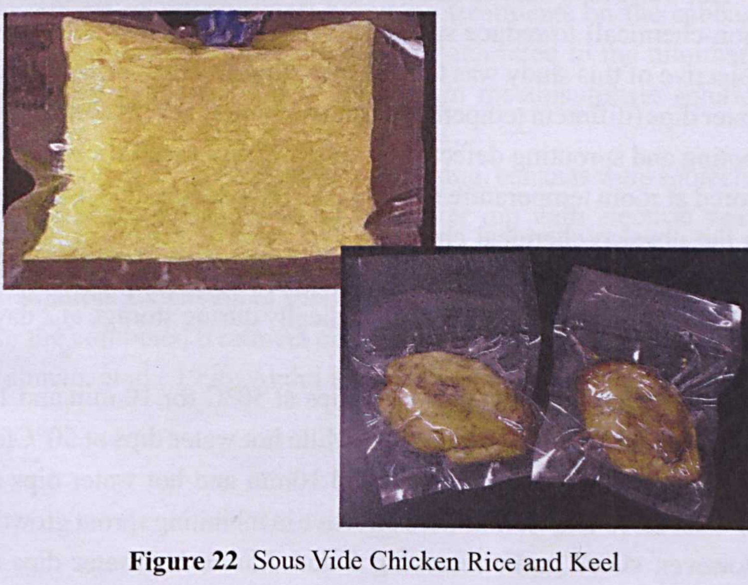

Figure 22 Sous Vide Chicken Rice and Keel

D. MINIMAL PROCESSING

Effect of Hot Water Dips in Controlling Rooting and Sprouting of Minimally Processed Sliced Garlic (Allium sativum L.) during storage at room temperature

Minimally processed (MP) fruits and vegetables are an important new product sector due to their fresh like character and convenience for ready to use and cook. Sliced garlic is one of the minimally processed products that have increased greatly in usage volume over the past few years. According to Shewfelt (1987), mechanical injuries speed up the deterioration rate of fresh produce by disrupting membranes and increasing enzymatic activity, which causes undesirable reactions to occur. This may cause browning, softening, off flavour development, moisture loss, surface discolouration and microbial spoilage that can contribute to a reduction in shelf life and loss of quality of minimally processed fruits and vegetables.

Hot water dips were considered as one of the potential treatments (non-chemical) to reduce sprout and root growths. Therefore, the objective of this study was to determine the effects of different hot water dips (different temperatures and dipping times) in controlling rooting and sprouting defects of minimally processed sliced garlic stored at room temperature (28°C ± 1°C, RH 75% ± 5%). Changes in the physico-chemical characteristics such as crispness, sprout and root growth, degree of browning and polyphenol oxidase (PPO) activity were examined periodically during storage at 2 days intervals.

Control samples and hot water dips at 50°C for 10 min and 15 min did not inhibit sprout growth, while hot water dips at 50°Cfor 20 min, 55°C for 5min, 7.5min and 10min and hot water dips at 60°Cfor 2.5, 5 and 7.5min were effective in inhibiting sprout growth. However, sliced garlic receiving 5 and 7.5min hot water dips at 60°C were visibly damaged Hot water dips for all temperatures and dipping times (50°C° for 10,15 and 20 min, 55°C for 5, 7.5 and 10 min and 60°C for 2.5, 5 and 7.5 min) were effective in inhibiting root growth as compared to control. Results of the present study indicate that crispness and degree of browning during storage were not affected by the hot water dips at all temperatures and exposure times. Activity of PPO was low at 50°C for 10min and was found to be more heat stable, and has higher activity when dipped at 60°C for 5 and 7.5 min (Abdul Rahim et al., 2006).

Minimal Processing of Cabbage

In this study, cabbage was shredded and packed into different packaging materials and changes over storage periods were observed especially on the biochemical and microbiological aspects (Ibrahim et al., 2005a). The shredded cabbage was also evaluated in terms of sensory attributes and changes in physical characteristics over different storage conditions (Ibrahim et al., 2005b). Study on the effects of different anti-browning treatments on the cabbage found that browning was successfully inhibited in the minimally processed cabbage using 0.1% sodium metabisulphate solution (Ibrahim et al., 2004).

In another study on minimal processing, bananas were subjected to combination treatments of hot water dip with electron beam irradiation at different hot water temperatures and doses of irradiation. Extension of shelf life of more than 50% was recorded for the combined treatment compared to non treated fruits (Abdul Rahman, et al., 1996; Abdul Rahman et. al., 1993).

E. OTHER TECHNOLOGIES

Osmotic Dehydration Combined with Freezing of Papaya

The effect of combined processes of osmotic dehydration and freezing on quality attributes of Malaysian cultivar *Sekaki* papaya cubes (15mm x 15mm x 15mm) with respect to moisture content, weight, total soluble solids, color, texture and drip loss were evaluated and compared to fresh produce. Osmotic system of sucrose solutions with 3 levels of concentration at 55°Brix, 60°Brix, and 65°Brix and at two temperature levels, 30°C and 40°C respectively were used to investigate the influence exerted on the aforesaid response variables variation during the osmodehyration stages periodically for 3 hours before fast freezing in air blast freezer operating at air flow rate of $10ms^{-1}$ and -35°C. The final product quality attributes were again evaluated upon being air thawed at room temperature. An affective test was also performed for frozen samples pretreated at 40°C for all three levels of sucrose concentration with 40 prescreened untrained panelists on a 9-point hedonic scale to investigate the organoleptic quality of the sample in comparison to controls. It was proposed that mild pre-treatment at 65°Brix sucrose concentration at 30°C for 90minutes would probably be the most preferable condition in improving the frozen papaya cubes quality attributes with a reasonably high dehydration efficiency index, WL/SG at 7.64±0.88 and quality characteristics as follow: mean moisture content level of 77.42%±0.03 w.b., mean TSS at 23.5±1.0 °Brix, mean F/F_0 of 1.063±0.199, mean L* value of 46.1±4.2, a* value of 30.0±2.5, and b* value of 37.4±6.9. Affective testing on the other hand confirmed that the obtained partial water removal and sucrose enrichment did evidently improve the quality attributes of osmo-frozen papaya cubes as shown in Figure 23, with more attractive color and pleasant taste, with an overall affective score range from 4.35±2.36 to 5.00±2.10 for all levels of sucrose concentration imposed in comparison to the untreated frozen ones that scored the lowest at 3.25±1.66 and suffered from significant detrimental texture, excessive drip loss and taste deterioration during freezing; and were not regarded as superior as the fresh papaya cubes which scored the highest at 5.58±2.10 9 (Tan, 2008).

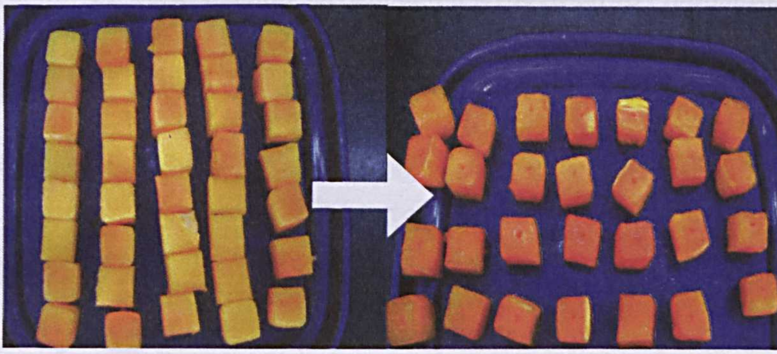

Figure 23 Osmodehydrated papaya cubes showed decreases in luminosity (L* value) and yellowness (b* value) and redness (a* value) enhancement:

From a) untreated intact papaya cubes at t_{OD} = 0min in comparison to; *b) punctured OD papaya cubes sampled every 30 minutes for penetration test*

Spray Drying of Durian Fruit Extract

This study was conducted to determine the effect of in-feed conditions that included the amount of drying aids, and the amount of water used to extract durian juice, on the product recovery of spray drying. Durian (*Durio zibethinus*) pulp extracted using different amounts of water (140-500%v/w of fruit pulp) was spray-dried using varying amounts of maltodextrin (50% to 100%w/w of fruit pulp) as the drying additive. Drying conditions that included drying temperature, heat air flow rate, atomization and in-feed flow rate were fixed throughout the study. Drying efficiency was evaluated in terms of the powder recovery. The highest recovery of durian powder, 89%, was obtained when 200%v/w water and 100%w/w maltodextrin were used. Results revealed that to achieve > 60% powder recovery, the use of maltodextrin can be reduced to 75%w/w by decreasing the amount of water used to 140% v/w for extraction. Powder recovery was heavily influenced by the initial in-feed solid amount which should be above 35°Brix for successful drying of durian extract. The powder with good recovery rates (> 60%) had no significant differences in terms of moisture content, bulk density and solubility (Chin et al., 2008; Chin et al., 2007: Chin et al., 2004).

Fruit Juice Processing

Similar to ready-to-eat concept for foods, researches on fruit juice processing for eventual development into ready-to-drink juices were also investigated. Several studies on juice processing were carried out especially on heating requirement for juice stability, physico-chemical changes during storage and effects of juice quality on maturity at harvest. A study on pink guava juice showed that at pasteurization temperatures between 60-90oC, the juice still preserved its pseudoplastic characteristics at TSS of 9oBrix and at 11oBrix (Zainal et al., 2001; Zainal et al., 2000). Maturity during harvest was found to be paramount for sugar cane juice quality as demonstrated by significant differences in chlorophyll and tannin contents, colour and ppo activity of the juice at different maturity stages (Qudsieh et al., 2002; Hannan et al., 2001). In another study, clarified sapodilla juice was successfully produced and optimized using hot water extraction and clarified using enzymes (Sin et al., 2006a; Sin et al., 2006b; Sin et al., 2005)

RECONSTITUTING CONVENIENCE FOODS

Most convenience foods need some form of minimal processing to reconstitute the food. Heating using hot water for packaged products has been used traditionally, as has the use of the conventional oven for heating of products in rigid containers capable of withstanding the oven temperatures. A more convenient method for the purpose of heating to reconstitute the food is the use of microwave ovens. However, in microwave heating the technique is not able to induce browning on the surface of foods. To alleviate this problem and aid the browning and crisping on the surface of a baked food item, a packaging material called susceptor has been developed specifically to support the usage of microwave ovens.

Susceptor Packaging material for Baking Flaky Pastry Dough in Microwave Oven

This study presents the design of susceptor packaging rigid box that is effective to bake flaky pastry dough (puff pastry) in microwave ovens and performance evaluation of the product through microwave testing.

Paperboard, corrugated board B-flute and metallized polyethylene terephthalate (MPET) film were used to design the susceptor packaging rigid box. Testing on performance of the susceptor packaging rigid box was implemented in microwave baking with different designs and lamination of packaging material with puff pastry inside. Only one design of susceptor packaging rigid box was chosen which was design eight which used semi coating MPET film based on the desirable quality of the susceptor packaging rigid box and the puff pastry. Quality parameters of puff pastries such as temperature after baking, weight loss, colour changes at top and bottom surfaces, specific volume after baking and hardness were obtained as a result of the application on susceptor packaging rigid box through microwave testing. The sensory attributes of puff pastries such as appearance (colour), odour, taste, crispiness, texture (hardness) and overall acceptability were also examined using Hedonic Test acceptability of panelists on the puff pastries that were baked in the susceptor packaging rigid box in microwave oven.

As baking time increased, all the quality parameters increased. Microwave baked puff pastries without susceptor packaging rigid box had some quality defects such as lack of colour, becoming soggy, shrinking and brittle when cold. However, the microwave baked puff pastries had the highest specific volume and temperature. It was possible to improve the quality of microwave baked puff pastries with the aid of the susceptor packaging rigid box. The colour of the puff pastries changed into desirable rich brown (Figure 24) and gave crispiness value similar to the conventionally baked ones at the three power levels used. However, microwave baked puff pastries in susceptor packaging rigid box had a lower volume at all powers used. The best conditions for baking puff pastries in microwave oven with susceptor packaging were 270s, 285s and 300s at 340W microwave power; l65s and l80s at 500W microwave power; and 105s and 120s at 790W microwave power. When susceptor packaging was applied for these conditions, it reduced conventional baking time by about 75%-91%. Results of sensory evaluation -showed that puff pastries baked in conventional ovens were highly accepted by the panelists with mean scores of 7.67 (mean scale: 1-9). This was followed by puff pastries baked in susceptor packaging rigid box with a mean score value of 6.93. Microwave baked puff pastries had the lowest mean score in overall acceptability (4.47) (Main, 2008; Main et al. 2007).

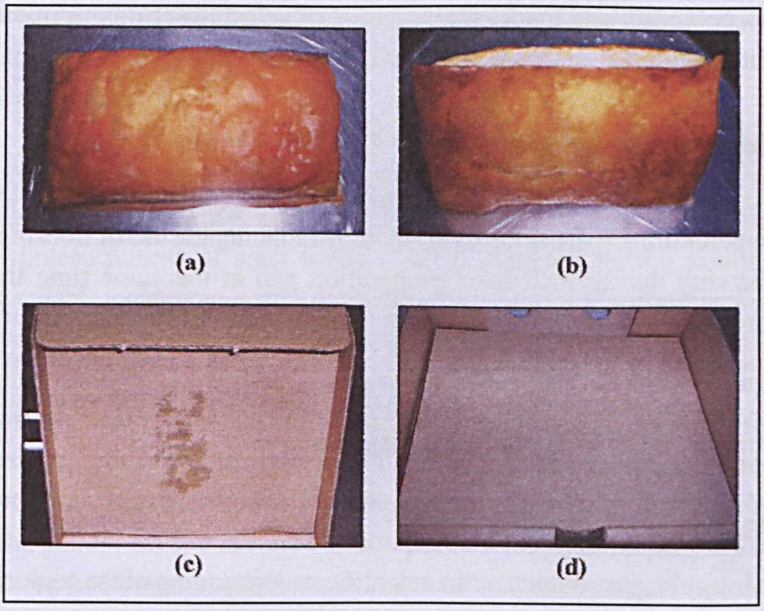
(a) (b) (c) (d)

Figure 24 Effect of Susceptor Packaging on Puff Pastry

R&D PROSPECTS IN MALAYSIA

Semi-convenient Foods

The need for convenience has led to changes in consumer preferences increasing the demand for ready prepared meals. In Malaysia, packaged and processed convenient foods have become increasingly common and increased consumption of semi-convenient foods is observed. Semi-convenient food products are such as those in ready made gravy, spices and sauces which can be used with raw or semi-cooked materials with minimum preparation. The development of such products and their successful marketing will hopefully improve the balance of trade and reduce importation since Malaysians have been observed to be influenced by this Western culture. Thus the objective of the study is to identify, improve and determine the acceptability and marketing potential of selected semi-convenient food products.

Superchilling in Foods

Extended shelf life of fresh food products can be obtained by superchilling (partial freezing) thereby reducing the use of freezing/thawing during final food preparation and at the same time the presence of ice in the product will protect from temperature increases in the cold chain. This technology is a possible answer to perceived problems in food safety of cook-chill and sous vide production of food products (Magnussen et al., 2008).

Molecular Gastronomy

Molecular gastronomy or the scientific understanding of the cooking and eating processes (Vega and Ubbink, 2008) is an emerging field in food science. Development of new dishes for both haute cuisine and normal fare will in the future require the use of equipment and materials commonly found in food laboratories. An example is the use of high speed blenders and homogenizers to come up with very fine and smooth textures in foods.

CONCLUSION

Lifestyles have evolved from the so-called traditional family consisting of one income-earning adult, a homemaker and children, to more complex situations involving two working parents, single working parent, and single career oriented adults. Today everybody is busier than ever and at the same time demand a life that is simpler and more convenient with new time saving techniques. There is a strong desire from consumers for high quality and convenient products such as desserts, ready prepared meals, freshly cut fruits and vegetables in convenient pack, pastas, meat and fish products and above all traditionally available products in a more readily available form.

The processing and preparation of these so called convenience foods need to consider several factors addressing issues of safety, acceptability, user friendly, nutritional and above all the wholesomeness of such foods. This is achieved by the existing available technologies such as chilling, freezing, minimal processing, heating, packaging and using emerging technologies as described above. Most of the time, food preparation needs the combination of these technologies. To prepare the convenience foods ready for consumption will also demand a fast and efficient reconstituting or reheating techniques. The use of microwave oven seems to be the answer for the moment as compared to the traditional ways of using hot water or conventional oven to heat the product

Hence the role played by food engineers and technologists is indeed very noble and brings harmony to the family. The less time they spend in the kitchen preparing meals, the more quality time they have with their family. This is done without sacrificing the safety and hygiene of convenience foods as described in this lecture. This is in fact a small contribution by food engineers and technologists in responding to changing lifestyles by engineering convenience foods for the betterment of society.

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BIOGRAPHY

RUSSLY ABDUL RAHMAN was born in Muar, Johor in 1957, a few weeks after Malaysia attained independence. He received his secondary education at the prestigious Malay College Kuala Kangsar, Perak. In 1976 he was offered a scholarship to study in U.K. where he did his 'A'-Levels at Southampton Technical College, Southampton and eventually went on to Nottingham University, Nottingham, where he obtained his honours Degree in Mechanical Engineering in 1981. After graduation and upon returning home to Malaysia he was offered several jobs in companies such as PETRONAS, ESSO, MSE and several others. However, due to his zeal to further his studies he declined all offers and instead applied for the position of Tutor (Trainee Lecturer) at Universiti Pertanian Malaysia (now Universiti Putra Malaysia) in 1981.

In 1982 he was sent to Reading University, UK on a Malaysian Government scholarship for his Master's degree in Food Process Engineering. Upon returning to Malaysia he was appointed as lecturer at the Department of Food Technology in 1983. After working for 5 years he was awarded another scholarship to pursue his doctoral degree at Reading University, UK. He obtained his PhD degree in Food Technology in 1992.

With this background he considers himself a food engineer with interest in food processing and packaging. Food Engineering is a relatively new branch of engineering derived basically from the Chemical/Mechanical/Agricultural engineering disciplines. He was promoted to Associate Professor in 1997, five years after obtaining his PhD degree and 7 years later to Professor in 2004.

As a lecturer, he was involved in teaching many subjects mainly related to food engineering and packaging. Some of the subjects he has taught include Fundamentals of Food Engineering, Food Unit Operations, Food Packaging, Food Packaging Equipment, Food

Process and Plant Design, Food Processing and Preservation, Food Plant Control, Halal Food Processing, Trends in Food Technology, etc.

The curriculum for the Food Science and Technology program at UPM consists of about 25% food engineering related subjects. During his early years as a lecturer he was involved in developing new subjects in food engineering, revising, reviewing and upgrading the existing subjects in the program. In 1988 he had the opportunity to go on a study visit to several UK universities with the objective of looking at the engineering content in their Food Science/Technology programs. This was conducted under the Commonwealth CICHE Program and the experience proved to be useful in the development of the curriculum in UPM.

Being in the academic world, supervising students has always been his interest. He has supervised more than 15 PhD candidates and more than 40 Masters students either as the main or co-supervisor.

Many of the research projects in Food Science and Technology are applied in nature. Hence a person of his background with experience in engineering and packaging disciplines is able to fit well in the field of multidisciplinary food research. As a result he finds himself involved in quite a number of graduate supervisory committees related to the professional areas of food engineering and packaging. Todate, Russly has conducted and participated in more than 25 research projects, and generated more than 200 publications more than 70 of which are in refereed journals. He has also presented papers at national and international conferences and seminars.

Appointment as a consultant is recognition by others of our ability to contribute to their organizational needs. Russly had the opportunity to be involved in more than 10 consultancy projects, heading four and being a team member in the others. Perhaps the most significant of these was the work on technology mapping for the food industry in Malaysia. This was a national project known as the NTMP II (National Technology Mapping Program II) for the food industry and was conducted for the EPU (Economic Planning Unit, Prime Minister's Department) and MIGHT (Malaysian Industry-Government Group for High Technology, Prime Minister's Department). The study involved identifying the present situation of the local food industries, identifying future trends and needs of the industry both locally and globally and finally to suggest and identify the missing links to fulfill the gaps between the present and the future. This was carried out by having discussion workshops with the industry, conducting surveys on identified companies, analysis and scenario building sessions and also benchmarking exercises on some of the world's best food companies. He was glad, as a leader for the consultants, that their recommendations and suggestions were used by the government to draft out policies for the food industry.

In 1997 Russly was appointed as the Head of Department for the Department of Food Technology, a post he held until 2003. During his tenure he was in-charge of a new academic program known as the BS(Food Studies) which comprised 4 options namely Food Quality Management, Food Service Administration, Food Management and Food Marketing. Because of the varied nature of the options, they were just like 4 different academic programs. One of the significant in-roads achieved in the development of the program was the planning and design of a food service complex known as the Industrial Kitchen. The purpose built industrial kitchen with state of the art facilities was, however, only completed in 2008.

Another contribution which he thought was very significant during his tenure as Head of the Food Technology Department was in the development of a Food Pilot Plant. Under the 'One-Off' projects' which was applied for through the Ministry of Education, the Faculty was allocated about RM 3 million to develop the project. With the support of the Faculty and the Department, the Pilot Plant eventually came into being with facilities for liquid food processing for juice and drinks, viscous product lines for pastes and gravies and some selected solid product processing. With such facilities the Faculty was able to undertake processing of food commodities at pilot scale level which proved to be useful for students to get hands-on training. This in-fact provides a different dimension in teaching students about food processing. Further, the facilities were also extended to entrepreneurs and small businesses to conduct trials in producing their products before they embarked on full scale commercialization. It has also attracted students from other universities (local and abroad) to do their practical training.

In August 2004 Russly was seconded to the Engineering Faculty, UPM in the Department of Process and Food Engineering with a special mission to head the Department. As a food engineer he fit well at the Department and was able to provide leadership to a relatively 'young' Department. With participation and contribution from everybody, the Department grew from strength to strength, participating in all academic activities such as teaching, research, consultancy, curriculum development, students' development, etc. After 2 years at the Engineering Faculty, he was transferred back to the Faculty of Food Science and Technology to the post of Deputy Dean, beginning August 2006. However, he still maintains his contributions to the engineering department as a professor, teaching, postgraduate and undergraduate students' supervision, research activities and other academic obligations.

At the University, Faculty and Department levels, he serves in various committees and is ever ready to contribute in whatever way necessary. In April 2008, Russly was appointed as a Senate member of UPM to represent the Faculty of Food Science and Technology. At the national level he is involved in committees such as the SIRIM Technical Committees on Packaging, Food Packaging, and Food Irradiation, where he chairs the Technical Committee on Packaging. He also participates in various committees in the Ministry of Health, Ministry of Agriculture and Ministry of Science, Technology and Innovation. He was also appointed as reviewer for a number of local and international scientific journals and sits on the editorial board of the International Journal of Food Research, formerly known as the ASEAN Food Journal. He also sits as penal member for the MQF (Malaysian Quality Framework) to evaluate new programs related to Food Science, Technology or Engineering. He was also appointed External Examiner and Assessor for an undergraduate program at University Kuala Lumpur.

At the international level Russly participated in the teaching of the Asian-European Master's Degree of Science in Food Science and Technology. Further he is the Malaysian representative for the International Society for Food Engineering. He has received a number of awards such as the Excellent Service Achievement Award for the years 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000 and 1997. He also received some medals (Gold, Silver and Bronze) at University and National research competitions. He sincerely believes that he has contributed his best in the three functions of a university lecturer, namely teaching, research and professional duties. These contributions will hopefully be of benefit to the students, to the Department, the Faculty, UPM, to this beloved country and to the whole world, if possible.

He would like to take this opportunity to sincerely thank his graduate students (past and present), for their contributions to his success, as well as his colleagues and staff. He is forever indebted to his family particularly his beloved wife, Fuziah (who is a Member of Parliament for Kuantan), his children Sara, Aliyya, Hafidz, Muiz, Ruwaida and Ulfah, to his sons-in-law Halim and Baha and his grandchildren Yaya, Amji and Akish. May Allah bestow us with mercy, wisdom and 'hidayah' to proceed in this ever changing and challenging world.

ACKNOWLEDGEMENTS

In the name of ALLAH Most Gracious, Most Merciful. It is with His help and blessing that I have reached to this level of my life journey, utilizing the potentials that He has bestowed in me to serve Him and also to contribute in whatever little capacity that I have for the betterment of human life.

I would like to take this opportunity to express my heartfelt gratitude and appreciation to the following who have made it possible for me to have reached to the position that I am today: Pn Asiah Zain, Prof. Dr Gulam Rusul Rahmat Ali, Prof. Dr Yaakob Che Man, Prof. Jinap Selamat, Prof. Dr Ali Hassan, colleagues and staffs from the Faculty of Food Science and Technology and Faculty of Engineering, my research collaborators both within and outside UPM, my postgraduate students, my undergraduate students, my industry friends and to all those who have contributed directly or indirectly to my success. It is a real pleasure to have known and work with all of you.

I would also like to take this opportunity to sincerely thank Universiti Putra Malaysia and sponsors of my research grants for the opportunities rendered to me to persue my interests in research, to explore and to excel in my areas of expertise.

Last but not least, my deepest gratitude to my beloved wife (Fuziah), my children (Sara, Aliyya, Hafidz, Muiz, Ruwaida and Ulfah), my grandchildren (Hanzalah, Hamzi and Balqis) and to my loving parents for their doa, sacrifices, understanding, endless support and above all their unfailing love.

his family particularly his beloved wife [illegible] of Parliament for Kuantan), his children Irna, Aliyya, Hafidz, Muiz, Rawaida and Ulfah, to his sons-in-law, [illegible] grandchildren [illegible]. May Allah bestow us with energy, wisdom and strength to succeed in this ever changing and challenging world.

LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
   The Challenge to Communication Research in Extension
   22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
   Indigenous Materials and Technology for Low Cost Housing
   30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
   Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
   30 January 1993

4. Prof. Dr. Mohamed Suleiman
   Numerical Solution of Ordinary Differential Equations: A Historical Perspective
   11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
   Changing Roles of Agricultural Economics
   5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
   Marketing Management: Prospects and Challenges for Agriculture
   6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
   The Changing Demand for Livestock Products
   20 April 1994

8. Prof. Dr. Ruth Kiew
   Plant Taxonomy, Biodiversity and Conservation
   11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
   Engineering Technological Developments Propelling Agriculture into the 21st Century
   28 May 1994

10. Prof. Dr. Shamsuddin Jusop
    Rock, Mineral and Soil
    18 June 1994

11. Prof. Dr. Abdul Salam Abdullah
Natural Toxicants Affecting Animal Health and Production
29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
Pest Control: A Challenge in Applied Ecology
9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
Managing Challenges in Fisheries Development through Science and Technology
23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
Sejarah Keagungan Bahasa Melayu
6 Ogos 1994

15. Prof. Dr. Law Ah Theem
Oil Pollution in the Malaysian Seas
24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
Fine Chemicals from Biological Resources: The Wealth from Nature
21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
Health, Disease and Death in Creatures Great and Small
25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
Fish Health: An Odyssey through the Asia - Pacific Region
25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
Chromosome Distribution and Production Performance of Water Buffaloes
6 May 1995

20. Prof. Dr. Abdul Hamid Mahmood
Bahasa Melayu sebagai Bahasa Ilmu- Cabaran dan Harapan
10 Jun 1995

21. Prof. Dr. Rahim Md. Sail
Extension Education for Industrialising Malaysia: Trends, Priorities and Emerging Issues
22 July 1995

22. Prof. Dr. Nik Muhammad Nik Abd. Majid
The Diminishing Tropical Rain Forest: Causes, Symptoms and Cure
19 August 1995

23. Prof. Dr. Ang Kok Jee
The Evolution of an Environmentally Friendly Hatchery Technology for Udang Galah, the King of Freshwater Prawns and a Glimpse into the Future of Aquaculture in the 21st Century
14 October 1995

24. Prof. Dr. Sharifuddin Haji Abdul Hamid
Management of Highly Weathered Acid Soils for Sustainable Crop Production
28 October 1995

25. Prof. Dr. Yu Swee Yean
Fish Processing and Preservation: Recent Advances and Future Directions
9 December 1995

26. Prof. Dr. Rosli Mohamad
Pesticide Usage: Concern and Options
10 February 1996

27. Prof. Dr. Mohamed Ismail Abdul Karim
Microbial Fermentation and Utilization of Agricultural Bioresources and Wastes in Malaysia
2 March 1996

28. Prof. Dr. Wan Sulaiman Wan Harun
Soil Physics: From Glass Beads to Precision Agriculture
16 March 1996

29. Prof. Dr. Abdul Aziz Abdul Rahman
Sustained Growth and Sustainable Development: Is there a Trade-Off 1 or Malaysia
13 April 1996

30. Prof. Dr. Chew Tek Ann
Sharecropping in Perfectly Competitive Markets: A Contradiction in Terms
27 April 1996

31. Prof. Dr. Mohd. Yusuf Sulaiman
Back to the Future with the Sun
18 May 1996

32. Prof. Dr. Abu Bakar Salleh
Enzyme Technology: The Basis for Biotechnological Development
8 June 1996

33. Prof. Dr. Kamel Ariffin Mohd. Atan
The Fascinating Numbers
29 June 1996

34. Prof. Dr. Ho Yin Wan
Fungi: Friends or Foes
27 July 1996

35. Prof. Dr. Tan Soon Guan
Genetic Diversity of Some Southeast Asian Animals: Of Buffaloes and Goats and Fishes Too
10 August 1996

36. Prof. Dr. Nazaruddin Mohd. Jali
Will Rural Sociology Remain Relevant in the 21st Century?
21 September 1996

37. Prof. Dr. Abdul Rani Bahaman
Leptospirosis-A Model for Epidemiology, Diagnosis and Control of Infectious Diseases
16 November 1996

38. Prof. Dr. Marziah Mahmood
Plant Biotechnology - Strategies for Commercialization
21 December 1996

39. Prof. Dr. Ishak Hj. Omar
Market Relationships in the Malaysian Fish Trade: Theory and Application
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40. Prof. Dr. Suhaila Mohamad
Food and Its Healing Power
12 April 1997

41. Prof. Dr. Malay Raj Mukerjee
A Distributed Collaborative Environment for Distance Learning Applications
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42. Prof. Dr. Wong Kai Choo
Advancing the Fruit Industry in Malaysia: A Need to Shift Research Emphasis
15 May 1999

43. Prof. Dr. Aini Ideris
Avian Respiratory and Immunosuppressive Diseases- A Fatal Attraction
10 July 1999

44. Prof. Dr. Sariah Meon
Biological Control of Plant Pathogens: Harnessing the Richness of Microbial Diversity
14 August 1999

45. Prof. Dr. Azizah Hashim
The Endomycorrhiza: A Futile Investment?
23 Oktober 1999

46. Prof. Dr. Noraini Abdul Samad
Molecular Plant Virology: The Way Forward
2 February 2000

47. Prof. Dr. Muhamad Awang
Do We Have Enough Clean Air to Breathe?
7 April 2000

48. Prof. Dr. Lee Chnoong Kheng
Green Environment, Clean Power
24 June 2000

49. Prof. Dr. Mohd. Ghazali Mohayidin
Managing Change in the Agriculture Sector: The Need for Innovative Educational Initiatives
12 January 2002

50. Prof. Dr. Fatimah Mohd. Arshad
Analisis Pemasaran Pertanian di Malaysia: Keperluan Agenda Pembaharuan
26 Januari 2002

51. Prof. Dr. Nik Mustapha R. Abdullah
Fisheries Co-Management: An Institutional Innovation Towards Sustainable Fisheries Industry
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52. Prof. Dr. Gulam Rusul Rahmat Ali
Food Safety: Perspectives and Challenges
23 March 2002

53. Prof. Dr. Zaharah A. Rahman
Nutrient Management Strategies for Sustainable Crop Production in Acid Soils: The Role of Research Using Isotopes
13 April 2002

54. Prof. Dr. Maisom Abdullah
Productivity Driven Growth: Problems & Possibilities
27 April 2002

55. Prof. Dr. Wan Omar Abdullah
Immunodiagnosis and Vaccination for Brugian Filariasis: Direct Rewards from Research Investments
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56. Prof. Dr. Syed Tajuddin Syed Hassan
Agro-ento Bioinformation: Towards the Edge of Reality
22 June 2002

57. Prof. Dr. Dahlan Ismail
Sustainability of Tropical Animal-Agricultural Production Systems: Integration of Dynamic Complex Systems
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58. Prof. Dr. Ahmad Zubaidi Baharumshah
The Economics of Exchange Rates in the East Asian Countries
26 October 2002

59. Prof. Dr. Shaik Md. Noor Alam S.M. Hussain
Contractual Justice in Asean: A Comparative View of Coercion
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60. Prof. Dr. Wan Md. Zin Wan Yunus
Chemical Modification of Polymers: Current and Future Routes for Synthesizing New Polymeric Compounds
9 November 2002

61. Prof. Dr. Annuar Md. Nassir
Is the KLSE Efficient? Efficient Market Hypothesis vs Behavioural Finance
23 November 2002

62. Prof. Ir. Dr. Radin Umar Radin Sohadi
Road Safety Interventions in Malaysia: How Effective Are They?
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63. Prof. Dr. Shamsher Mohamad
The New Shares Market: Regulatory Intervention, Forecast Errors and Challenges
26 April 2003

64. Prof. Dr. Han Chun Kwong
Blueprint for Transformation or Business as Usual? A Structurational Perspective of the Knowledge-Based Economy in Malaysia
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65. Prof. Dr. Mawardi Rahmani
Chemical Diversity of Malaysian Flora: Potential Source of Rich Therapeutic Chemicals
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66. Prof. Dr. Fatimah Md. Yusoff
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67. Prof. Dr. Mohamed Ali Rajion
The Essential Fatty Acids-Revisited
23 August 2003

68. Prof. Dr. Azhar Md. Zain
Psychotheraphy for Rural Malays - Does it Work?
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69. Prof. Dr. Mohd. Zamri Saad
Respiratory Tract Infection: Establishment and Control
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70. Prof. Dr. Jinap Selamat
Cocoa-Wonders for Chocolate Lovers
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71. Prof. Dr. Abdul Halim Shaari
High Temperature Superconductivity: Puzzle & Promises
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72. Prof. Dr. Yaakob Che Man
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73. Prof. Dr. Kaida Khalid
Microwave Aquametry: A Growing Technology
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74. Prof. Dr. Hasanah Mohd. Ghazali
Tapping the Power of Enzymes- Greening the Food Industry
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75. Prof. Dr. Yusof Ibrahim
The Spider Mite Saga: Quest for Biorational Management Strategies
22 May 2004

76. Prof. Datin Dr. Sharifah Md. Nor
The Education of At-Risk Children: The Challenges Ahead
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77. Prof. Dr. Ir. Wan Ishak Wan Ismail
Agricultural Robot: A New Technology Development for Agro-Based Industry
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78. Prof. Dr. Ahmad Said Sajap
Insect Diseases: Resources for Biopesticide Development
28 August 2004

79. Prof. Dr. Aminah Ahmad
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80. Prof. Dr. Abdul Razak Alimon
Challenges in Feeding Livestock: From Wastes to Feed
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81. Prof. Dr. Haji Azimi Hj. Hamzah
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29 April 2005

82. Prof. Dr. Rasedee Abdullah
In Search of An Early Indicator of Kidney Disease
27 May 2005

83. Prof. Dr. Zulkifli Hj. Shamsuddin
Smart Partnership: Plant-Rhizobacteria Associations
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84. Prof. Dr. Mohd Khanif Yusop
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85. Prof. Dr. Annuar Kassim
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86. Prof. Dr. Othman Mohamed
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87. Prof. Ir. Dr. Mohd Amin Mohd Soom
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88. Prof. Dr. Mohd Arif Syed
Bioremediation-A Hope Yet for the Environment?
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90. Prof. Dr. Norhani Abdullah
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91. Prof. Dr. Abdul Aziz Saharee
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Activating Teachers' Knowledge and Lifelong Journey in Their Professional Development
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Development and Innovation in the Fracture Management of Animals
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95. Prof. Dr. Zainal Aznam Md. Jelan
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96. Prof. Dr. Mahiran Basri
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98. Prof. Dr. Khalid Abdul Rahim
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100. Prof. Dr. Zainal Abidin Mohamed
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101. Prof. Ir. Dr. Mohamed Daud
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102. Prof. Dr. Saleha Abdul Aziz
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103. Prof. Dr. Jayum A. Jawan
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104. Prof. Dr. Zakariah Abdul Rashid
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106. Prof. Dr. Dzulkefly Kuang Abdullah
Palm Oil: Still the Best Choice
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107. Prof. Dr. Elias Saion
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108. Prof. Dr. Mohd Ali Hassan
Waste-to-Wealth Through Biotechnology: For Profit, People and Planet
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109. Prof. Dr. Mohd Maarof H. A. Moksin
Metrology at Nanoscale: Thermal Wave Probe Made It Simple
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110. Prof. Dr. Dzolkhifli Omar
The Future of Pesticides Technology in Agriculture: Maximum Target Kill with Minimum Collateral Damage
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111. Prof. Dr. Mohd. Yazid Abd. Manap
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112. Prof. Dr. Hamami Sahri
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113. Prof. Dato' Dr. Makhdzir Mardan
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114. Prof. Dr. Maimunah Ismail
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115. Prof. Dr. Nor Aripin Shamaan
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116. Prof. Dr. Mohd Yunus Abdullah
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117. Prof. Dr. Musa Abu Hassan
Memanfaatkan Teknologi Maklumat & Komunikasi ICT untuk Semua
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118. Prof. Dr. Md. Salleh Hj. Hassan
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119. Prof. Dr. Jariah Masud
Gender in Everyday Life
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120 Prof. Dr. Mohd Shahwahid Haji Othman
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121. Prof. Dr. Son Radu
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