QUALITY ATTRIBUTES OF BREAD USING MANGO (Mangifera indica) PEEL FLOUR.

by

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

PENAMBAHBAIKAN KUALITI ROTI DENGAN PENGGUNAAN TEPUNG KULIT MEMPELAM (*Mangifera Indica*).

ABSTRAK

Objektif kajian ini adalah untuk mengkaji kesan tepung komposit ke atas sifat-sifat fizikal, nutrisi dan sensori roti. Tepung roti putih digantikan dengan tepung kulit mangga (MPF) pada kadar 5 %, 10 % dan 15 %. Analisis fiziko-kimia dan sifat berfungsi kulit mangga (FMP) dan tepung kulit mangga juga dijalankan. Keputusan menunjukkan kadar penggantian tepung roti putih dengan MPF dari 5-15 % meningkatkan kandungan lembapan dan gentian kasar dan menurunkan kandungan protein, lemak dan karbohidrat. Kulit mangga dan tepungnya berserta dengan roti gantian MPF adalah kaya dengan elemen kalium. Kandungan maltose dan fructose FMP adalah lebih tinggi dengan signifikan ($p<0.05$) berbanding dengan MPF. Laktosa dapat dikesan dalam semua jenis roti. Kulit mangga mempunyai 95.48 mg/g kandungan jumlah fenolik dengan 2.58 µg/g GAE tindak balas radikal DPPH dan nilainya menurun dalam MPF. Jumlah kandungan fenolik dan tindak balas radikal DPPH meningkat dengan signifikan ($p<0.05$) dari roti kawalan ke roti 15 % MPF. Kandungan gentian dietari (TDF) MPF adalah lebih tinggi dengan signifikan ($p<0.05$) berbanding dengan kulit mangga. Kadar MPF dalam roti dari 5-15 % mengandungi 7.70-17.29 % TDF, 1.21-4.15 % gentian larut (SDF) dan 6.50-13.14 % gentian tak larut (IDF). Kanji rintang (RS) dalam FMP adalah 6.99 % dan MPF adalah 19.29 %. Kandungan kanji rintang meningkat dengan signifikan ($p<0.05$) secara langsung dengan peningkatan penggantian kadar MPF dalam roti. Nilai kanji MPF adalah berganda (30.73 %) berbanding dengan kulit mangga (14.58 %). Peningkatan kadar MPF dalam roti akan menurunkan ($p<0.05$) kandungan kanji. Tepung kulit mangga mempunyai kesan penurunan glisemik indek (GI) dengan signifikan ($p<0.05$). Roti dengan 15 % MPF merupakan makanan rendah GI. Isipadu lof menurun dengan signifikan ($p<0.05$) dengan penggantian MPF. Warna roti juga dipengaruhi oleh penggantian MPF dengan signifikannya ($p<0.05$). Parameter kecerahan warna roti yang diganti dengan kadar MPF yang berlainan menurun. Mikrograf SEM menunjukkan pelbagai bentuk dan saiz granul kanji dan sel gas. Roti adalah masih selamat dimakan selama 3-4 hari. Penilaian sensori roti 5 % MPF didapati mencapai penerimaan keseluruhan yang paling tinggi dalam penentuan sensori.

QUALITY ATTRIBUTES OF BREAD USING MANGO (*Mangifera indica*) PEEL FLOUR.

ABSTRACT

The objective of this research was to evaluate the physical, nutritional and sensory attributes of composite flour breads. Substitutions of white bread flour with mango peel flour (MPF) were carried out at 5 %, 10 % and 15 % levels. Physico-chemical and functional properties of both fresh mango peel (FMP) and mango peel flour (MPF) were also determined. Increasing levels of substitution with MPF 5-15 % to white bread flour significantly increased ($p<0.05$) the moisture and crude fibre content and decreased the protein, fat and carbohydrate. The FMP and MPF substituted bread were rich in potassium. Fresh mango peel contained significantly ($p<0.05$) higher amounts of maltose and fructose compared to MPF. Lactose was detected in all MPF breads. Fresh mango peel consist of 95.48 mg/g of total phenolics with 2.58 µg/g of GAE scavenging DPPH radical. Total phenolics content and scavenging effect increased significantly ($p<0.05$) from the control bread to 15 % MPF bread. The MPF had significantly ($p<0.05$) higher amount of total dietary fibre (TDF) as compared to the fresh peel. Levels of MPF in breads from 5-15 % contained 7.70-17.29 % TDF, with 1.21-4.15 % of soluble dietary fibre (SDF) and 6.50-13.14 % of IDF. Resistant starch (RS) in FMP was 6.99 % and MPF had 19.29 %. Hence, RS content increased significantly ($p<0.05$) corresponding with the levels of MPF in bread. The total starch of MPF doubled (30.73 %) as compared to the mango peel (14.58 %). Bread with increased MPF will lower the total starch content ($p<0.05$). Substitution with different levels of MPF had a significant $P(<0.05)$ effect on glycemic index (GI). The 15 % MPF bread was rated as low GI food.

The bread volume decreased significantly ($p<0.05$) with the increasing level of MPF. The colour of the breads was also significantly ($p<0.05$) affected by substitution of MPF. The colour of bread substituted with different levels of MPF decreased in lightness value. SEM micrographs showed various shapes and sizes of starch and gas cells. All bread samples were still safe to eat after 3-4 days. Sensory evaluation showed that the 5 % MPF bread had the highest overall acceptability score.

CHAPTER 1
INTRODUCTION

1.0 Introduction

Diets rich in fruits and vegetables are gaining importance due to their significant role in reducing the risk of certain types of cancer, cardiovascular diseases and other chronic diseases (Criqui and Ringel, 1994; Hertog *et al*., 1993; Joshipura *et al*., 2001). Maintaining a healthy diet is the practice of making choices about what to eat with the intent of improving or maintaining good health. Usually this involves consuming the necessary nutrients from all food groups. Since human nutrition is complex, a healthy diet varies widely depending on the individual's genetic makeup, environment and health. Lack of food and malnutrition are the main impediments to healthy eating. It is popularly misperceived that a healthy diet is attainable by eating substances often deem as healthy food.

The consumption of substances that are deemed healthy, such as an "all-grain diet" or a diet consisting only of pasta would most likely result in deficiencies because other important nutrients (like protein-based foods) would be missed. Foods such as grains, fish and corn are healthy when consumed in a balanced diet. Milk, cheese and other dairy products are known to have a relatively high fat content. Replacement of dairy products from a diet may lower the fat ingestion and affect the intake of calcium and riboflavin. The most important aspect of any diet is maintaining a healthy intake of balance foods.

Mango is considered as fruit of excellence. The delicious flavour, attractive fragrant and good nutritional value has gained a prominent position among commercial fruits in the international market. Mango is one of the most important tropical fruits and India ranks first in the world production of mangoes (Larrauri *et al*., 1996). The varieties available in Malaysia are the Chokanan, Harumanis, Nam Dork Mai, Maha and many more. Chokanan can be easily obtained in the local market.

Unripe mango fruits have been reported as a source for dietary fibre due to the starch content, high cellulose, hemicellulose, lignin and carotenoid composition (Vergara-Valencia *et al*., 2007). However, mango is a climacteric and seasonal fruit which is usually consumed in the ripe state. Hence, only about 20 % of the fruits are processed to products such as puree, nectar, leather, pickles and canned slices (Loelillet, 1994). In Malaysia, mango fruits are eaten fresh or are processed into juice, puree, jams, pickles and canned mango slices (Augustin *et al.*, 1987).

Peel is a major by-product during processing of mango. Currently, peel is not utilized for any commercial purpose and is discarded as a waste and became a source of pollution. The concern is specifically with utilization rather than disposal. The waste is of interest in those emerging from food processing factories. After utilization of mango pulp, the peels remain as waste. The by-products of peel and stones represented 35-60 % of the total fruit weight, depending on the cultivars and types of processed product. Disposal of large quantities of mango waste is a serious problem in the fruit industry.

Interest in utilization of the waste material stimulated studies on the application of mango by products. Juice, wine, vinegar and good quality pectins have been produced from the peels (Dabhade *et al.*, 1980; Pedroza-Islas *et al.*, 1994). Mango peel has been reported to contain a number of valuable compounds such as polyphenols, carotenoids, enzymes and dietary fibre (Ajila *et al*., 2007b). Larrauri *et al*. (1996) stated that dietary fibre from mango peel contained high proportion of soluble dietary fibre and total extractable polyphenols which meet the requirement of the food industry in a fibre-rich product containing bioactive compounds. Vergara-Valencia *et al*. (2007) also noted that unripe mango fruit is a suitable source for antioxidant dietary fibre concentrates.

Bakery products particularly bread is considered to be the best source to increase the dietary fibre content. Bakery products are highly consumed and act as the principal source of nutrition. Bread is a popular food in Western and most other countries, although East Asian societies typically preferred rice or noodles. It can be enriched with various types of functional additives and new types of raw material to maintain and enhance the bread quality. The US Department of Health and Human Services claimed that bakery products particularly bread, take a significant share in the food guide pyramid for daily food choices recommended. The working class and school children mainly consumed wheat in the form of bread and biscuits. The positive image of dietary fibre has prompted health conscious consumers to increase the purchase of foods containing wide range of fibre such as bread (Zhang and Moore, 1999). Bakery products with dietary fibre from mango was reported to have low predicted glycemic indices and thus may be used as dietary aid by people with special low caloric requirements (Vergara-Valencia *et al*., 2007). Hence, the under-utilized mango peel with promising commercial status could be harnessed. Utilization of these mango wastes will reduce the disposal problem and bring benefits in the production of mango products.

The primary objective of this study is to investigate the under-utilized mango peel from *Mangifera indica var.* Chokanan in terms of the following;

1. To study the chemical and functional properties of mango (*Mangifera indica* L. var. Chokanan) peel (FMP) and mango peel flour (MPF).

2. To evaluate the chemical, physical and sensory properties of the bread incorporated with different levels of MPF.

3. To investigate the microstructure of FMP and MPF and the effect of heat treatment on the microstructure of bread incorporated with different levels of MPF.

CHAPTER 2
LITERATURE REVIEW

2.0 Mango

Genus *Mangifera* belongs to the order Sapindales in the family Anacardiaceae which is a family of mainly tropical species with 73 genera (c. 850 species), with a few representatives in temperate regions. The genus *Mangifera* consists of 69 species and is mostly restricted to tropical Asia. Description and taxonomy of mango is shown in Table 2.1. The highest diversity of mango occurs in Malaysia, particularly in Peninsular Malaysia, Borneo and Sumatra. The natural occurrence of all the *Mangifera* species extends as far north as 27^{o} latitude and as far as the Caroline Islands. Wild mangoes occur in India, Sri Lanka, Bangladesh, Myanmar, Sikkim, Thailand, Kampuchea, Vietnam, Laos, southern China, Malaysia, Singapore, Indonesia, Brunei, the Philippines, Papua New Guinea, the Solomon and Caroline Islands. Maximum species diversity exists in western Malaysia. The exact origins of the mango are unknown, but are believed that it is native to Southern and Southeast Asia owing to the wide range of genetic diversity in the Asia region and fossil records dating back 25 to 30 million years (Subramanyam *et al.*, 1975).

Over 500 named varieties of mangoes have evolved and described in India with at least 350 varieties propagated in commercial nurseries. In the year 1958, 24 mango cultivars were described as among the important commercial types in India. India is by far the largest producer, with an area of 16,000 km^2

with an annual production of 10.8 million tones. This amount has contributed to 57.18 % of the total world production (Morton, 1987).

Table 2.1: Description and taxonomy of mango.

Kingdom	Plantae
Phyllum	Magnoliophyta
Class	Magnoliopsida
Order	Sapindaes
Family	Anacardiaceae
Genus	*Mangifera*
Species	*Indica*
Common names	Mango, an lo kuo, anbah, manga agaci, manga, mangot fil, mangot, manguier, mamuang, aangga, merpelam, pelem.
Part Used	Fruit, seed, leaves, bark, latex.
Documented Properties and Actions	Anti-asthmatic, antiseptic, antiviral, cardiotonic, emetic, expectorant, hypotensive, laxative.

(Source: Subramanyam *et al.*, 1975)

2.1 Nutrients

According to Wu *et al*. (1993), a whole fresh mango composed of 33–85 % of the edible pulp, 7–24 % of the peel and 9–40 % of the kernel. Mango fruit is described as a blend of sweetness and acidity, contains a high concentration of sugar (16–18 % w/v) and acids as well as antioxidants like carotene as Vitamin

A (Reddy and Reddy, 2005). Table 2.2 shown the food value of ripe mango flesh.

Table 2.2: Food value per 100 g of ripe mango flesh.

Fruit	
Calories	62.10-63.70 kcal
Moisture	78.90-82.80 g
Protein	0.36-0.40 g
Fat	0.30-0.53 g
Carbohydrates	16.20-17.18 g
Fibre	0.85-1.06 g
Ash	0.34-0.52 g
Calcium	6.10-12.80 mg
Phosphorus	5.50-17.90 mg
Iron	0.20-0.63 mg
Vitamin A (carotene)	0.14-1.87 mg
Thiamine	0.02-0.07 mg
Riboflavin	0.03-0.07 mg
Niacin	0.03-0.70 mg
Ascorbic Acid	7.80-172.00 mg
Tryptophan	3.00-6.00 mg
Methionine	4.00 mg
Lysine	32.00-37.00 mg

(Source: Morton, 1987).

Mango fruit has high carotenoid content which gave the ripe mango flesh yellow to orange colour. Carotenoid also provides a high provitamin A value and antioxidative capacity. The total carotenoid concentrations are usually in the range of 0.90–9.20 mg/100 g. However, a type of Indian cultivar ‘Alphonso’ showed an exceptionally high values of 11 mg/100 g carotenoid (Pott *et al*., 2003). According to Pott *et al*. (2003), β-carotene is generally the predominant carotenoid, comprising of 48–84 % of the total carotenoid concentrations. The nutritional importance of mango is mainly due to its initial concentration of β-carotene content which has been reported to be a cancer-preventing agents (Hymavathi and Khader, 2005; Reddy and Reddy, 2005). Furthermore, carotene acts as antioxidants and vitamin A precursors (Handelman, 2001). In addition to carotene, ascorbic acid and dietary fibre is also available in mangoes (Hymavathi and Khader, 2005). The unripe mango has been reported to be suitable source of antioxidant and dietary fibre concentrates (Vergara-Valencia *et al*., 2007).

The composition of mango lipids has been studied by Pott *et al*. (2003). They noted that biochemical changes occurred during acetylene-induced ripening in the cultivar 'Alphonso' and reported that C16:0, C16:1 and C18:1 were the main fatty acids of neutral lipids.

Polysaccharides can improve the thickening properties in aqueous systems, which is important in the manufacturing, distribution, storage and consumption of food products. Pectin is an acidic polysaccharide and is found in high concentrations in mango pulp. The pectin yield, degree of esterification and gel strength of the product depends on the type of raw material used (variety, conditions of processing) and the extraction process (Iaghar *et al*., 2002).

Unripe mango is rich in starch which is hydrolyzed to reducing sugars during ripening (Anon, 1962). During ripening, there was a decrease in starch content and an increase in the reducing and non-reducing sugars during ripening (Fuchs *et al*., 1980). Sucrose, glucose and fructose are the principal sugars in ripened mango, with small amounts of cellulose, hemicellulose and pectin. Ripening of mango is characterized by a gradual softening of the fruit, due to the progressive depolymerization of pectic and hemicellulosic polysaccharides with significant loss in galactose, arabinose and mannose residues at the ripe stage (Yashoda *et al*., 2005). The immature fruit have citric acid, malic acid, oxalic acid, succinic and other organic acids. In mature mango fruit, malic acid is the main organic acid (Giri *et al*., 1953).

Vergara-Valencia *et al*. (2007) reported that bakery products added with mango dietary fibre (MDF) had higher total dietary fibre (TDF) than respective controls and the products maintained significant antioxidant capacity. In addition, bakery products with added MDF have been reported to have low predicted glycemic index which can be applied in foods with low caloric requirements.

2.2 Post harvest and processing

Mangoes are generally harvested at physiological matured stage and ripened for optimum quality. Fruits are hand-picked or plucked with a machine harvester. During harvesting, the fruit latex trickled down the fruit surface from the point of detachment and resulted in a shabby appearance to the fruit upon storage. The fruit were heaped under a tree after harvesting and hence attributes to bruising and injuring the fruits. The injured fruits developed brown to black spots makes the fruits unattractive. The injured peel or stalk end further served as avenues for invasion of microorganism which leads to the rotting of mango fruits. The post harvest losses in mangoes have been estimated to be of 25-40 % from harvesting to consumption stage (Subramanyam *et al.*, 1975). This post harvest losses could be minimize by adopting proper methods of harvesting, handling, transportation and storage.

2.2.1 Nutrients changes during processing

Mango is a highly perishable fruit which is prone to degradation especially to nutrient loss during processing. Brecht (1995) and Watada *et al*. (1996) pointed out that some basic operations of minimal processing, such as peeling and slicing can result in quality changes to the fruit. The processing effect can be reduced by sulphiting which helps to retain an attractive colour in fruits (Salunkhe, 1974).

Drying is a good preservation technique to reduce the water activity in fruit. However, long term drying will cause undesirable effects such as discolouration like bleaching or browning (Kameni *et al*., 2003). Insufficient drying decreases the shelf life of the product which is resulted from microbial spoilage. Drying also contributes to partial degradation of xanthophylls and all trans-β-carotene (Pott *et al*., 2003). Krokida and Maroulis (2000) reported that browning of non-sulphited fruits during drying is typically caused by both enzymatic and nonenzymatic transformations, whereby the non-enzymatic Maillard reaction occurred during storage of the dried products. Baldry *et al*. (1976) noted that by spray drying of the mango pulp would produce good coloured powder without any unpleasant flavour. However, osmotic dehydration at mild temperatures preserves the flavour and colour of the fresh fruit (Heng *et al*., 1990).

2.3 Mango products

Mango processing is essential to maintain the freshness of mango product, stabilized and thus lengthen the shelf-life in the market. Hence, the processing of mango products which implies good stability and quality of mango products could be an option to increase trading in non-producing countries (Giraldo *et al*., 2003).

Solar drying is a relevant way of tackling inadequate storage facilities. Traditionally, sun-drying is carried out in preparing mango bar from ripe fruit pulp. Natural solar drying is currently the method to preserve fruit pulps. However, this traditional method has proven inefficient as it was implemented under unsanitary conditions and produced only a very limited number of products. More over, the sun-dried product is discoloured and browning is undesirable (Kameni *et al*., 2003). Reviews on ways of improving the quality of the naturally dried products using the natural solar drying method needed to be further studied as suggested by Toure´ and Kibangu-Nkembo (2004).

Cabinet drying has been carried out for making mango bar resulted in a better colour and flavour product (Heikal *et al*., 1972; Mir and Nath, 1995). Mango bars are manufactured by drying ripe mango puree into leathery sheets or bars. Pramanik and Sengupta (1978) reported that mango bar has very low protein content (1–2 %). The protein content of mango bars has been increased by the addition of shrimp flour and rice flour, whey protein isolate and soy protein isolate (Exama and Lacroix, 1989; Payumo *et al*., 1981; Chauhan *et al*., 1998). These bars are hygroscopic products with higher sugar content (Mir and Nath, 1995). Hygroscopicity refers to the ability of food to absorb moisture from high relative humidity environment (Jaya and Das, 2004). Absorption of moisture from the external atmosphere and non-enzymic browning during storage are the main problems as reported by Rao and Roy (1980). Water activity influences the product stability and the physical characteristics such as texture (Mir and Nath, 1995). Therefore, proper drying and adequate packaging are essential for maintaining the quality.

The extraordinary flavour, texture and colour characteristics of mangoes made it suitable as an ingredient in confectionaries. Mango pulp can be converted into jam, nectar, chutney, fruit bars and jellies. Mango juices and nectar are prepared by the addition of sugar and citric acid to achieve favourable total soluble solids and acidity, respectively.

Iaghar *et al*. (2002) studied the rheology of the mango pulp and noted that the mango pulp is highly viscous and exhibit pseudoplasticity property. Thus, the drying process of this sugar-rich mango pulp into powder is difficult, attributed by the low molecular weight sugars such as fructose, glucose, sucrose and citric acid present in the pulp (Jagtiani *et al*., 1988). More over, the mango pulps powder are very hygroscopic in their amorphous state and loose the free flowing nature at high moisture content (Jaya and Das, 2004).

The mango kernel is sun-dried and utilized as seasoning in various dishes (Joseph, 1995). Joseph (1995) also stated that after fat extraction, the residual of kernel cake could be used as thickener or a binder in the food and pharmaceutical industries. This kernel cake is a suitable substitute for hydrolysable carbohydrates used in diabetic-patient recipes (Joseph, 1995). Past research associated with utilizing seeds and fat from wild-mango fruits have been carried out on margarine, cooking oil, soap, perfumery and pharmaceutical products (Meara and Patel, 1950).

2.4 Medicinal application

The dried mango flowers which contain 15 % tannin serve as astringents in medical cases of diarrhea, chronic dysentery, catarrh of the bladder and chronic urethritis resulted from gonorrhea. The bark contains mangiferine which is astringent has been used against rheumatism and diphtheria in India. The resinous gum from the trunk is applied on the lesion on the feet and in scabies. The resinous gum is also believed to be beneficial in cases of syphilis (Morton, 1987).

Mango kernel decoction and powder (not tannin-free) are used as vermifuges and as astringents for diarrhea, hemorrhages and bleeding hemorrhoids (Morton, 1987). The fat is administered in cases of stomatitis. Extracts of unripe fruits and of bark, stems and leaves have shown antibiotic activity. In some of the islands of the Caribbean, the leaf decoction is taken as a remedy for diarrhea, fever, chest complaints, diabetes and other ills. A combined decoction of mango and other leaves is taken after childbirth (Morton, 1987).

2.5 Toxicity

Morton (1987) reported that the milky colour sap exudes from the stalk close to the base of the fruit turns pale-yellow and translucent when dried. This sap is reported to contain mangiferen, resinous acid, mangiferic acid and a type of resinol known as mangiferol (Morton, 1987). The toxicity of the sap from the stalk is observed to be similar to the sap of the trunk and branches as well as the skin of the unripe fruit. Mango sap has been observed to be a potent skin irritant and is capable to cause blistering of the skin of a normal individual (Morton, 1987). Individual with hypersensitive skin may react with mango sap resulting in swelling of the eyelids, the face and other parts of the body. Thus, a person with sensitive skin may not be able to handle, peel or eat any food containing residues of mango flesh or juice. Hence, different knives used to peel and slice the mango flesh is recommended to avoid contaminating the flesh with any of the resin in the peel (Morton, 1987).

The mango leaves contained mangiferine. In India, cows were formerly fed with mango leaves to obtain the urine which consist euxanthic acid. The euxanthic acid in urine causes a rich yellow colour has been used as a dye. This practice has been discontinued since continuous intake of the mango leaves may be fatal (Morton, 1987).

During the mango flower blooming season, the cases of people reported to suffer symptoms of itching around the eyes, facial swelling and respiratory difficulty is common, although there are no reports of airborne pollen. These health problems are the result of vaporized essential oil of the flowers which contains the sesquiterpene alcohol (mangiferol) and the ketone (mangiferone) (Morton, 1987). Hence, it is not advisable to use mango wood in fireplaces or for cooking fuel purposes as the smoke produced is highly irradiative.

2.6 Mango waste

During the processing of mango, the peel and stone are generated as waste (40-50 % of total fruit weight) (Larrauri *et al.*, 1996). These wastes are rich in various nutrients and many value added products could be obtained from them. Good quality jelly grade pectin (6.10 %) and edible fibre (5.40 %) could be extracted from the ripe mango peel. Acceptable quality vinegar (5.20 % acetic acid) and citric acid (20 g/kg peel) could be obtained from mango peel through microbial fermentation. Mango peel having low protein value (3.90 %) is a poor quality animal feed (Larrauri *et al.*, 1996). The peel could be protein enriched more than five times (20 %) by solid state fermentation using *Aspergillus niger*. Mango peel has lignocellulosic composition and hence its complete break down is difficult. Mango peel with cowdung co-composting in 3:1 ratio results in its successful biodegradation (Larrauri *et al.*, 1996).

After soaking and drying, the kernels are fed to the poultry and cattle. The feeding value is low considering the presence of tannin. Cuban scientists declared that the mineral levels are very low and mineral supplementation is needed if the kernel is used for poultry feed (Arogba, 1999).

Mango kernel contains high amount of carbohydrates, fat, protein and starch (Anand and Maini, 1997). The good quality oil extracted from the kernel could be used in the cosmetic and soap industries. About 10 % alcohol could be obtained from mango kernel by fermentation (Anand and Maini, 1997). In food processing industries, various enzymes are invariably used for pulp liquefaction and juice clarification. Enzymes such as cellulase and pectinase present in the mango peel and amylase from the mango kernel could be extracted through microbial fermentation (Larrauri *et al.*, 1996).

2.7 Mango peel

Mango peel is considered as a good source of dietary fibre as it is abundant in pectin content (Berardini *et al*., 2005a). Larrauri *et al*. (1996) showed that mango peels have high content of antioxidant (polyphenols) and soluble dietary fibre. The authors reported that a total of 7 % polyphenols and 13 % of uronic acid were found in mango peel. Polyphenolic compounds can enhance the stability of low density lipoprotein (LDL) to oxidation. It helps to prevent atherosclerosis and coronary heart disease (Anila and Vijayalakshmi, 2003). Kanner *et al*. (1994) stated that grapes, wines and grape by products contains large amount of phenolic compounds. Larrauri *et al*. (1997) reported that the amount of polyphenols in mango peel dietary fibre was only 3.7 times less than the well known French PARAD'OX wine polyphenols. Therefore, mango is a good source of dietary fibre with high antioxidant activities. High carotenoid content was found in fresh ripe mango which is responsible for the yellow to orange colour of ripe mango flesh, provides a high provitamin A value and antioxidative capacity. Litz (1997) reported that total carotenoid concentrations are usually in the range of 0.90–9.20 mg/100 g. Ajila *et al*., (2007a) observed that dietary fibre, carotenoid, vitamins C and E content was higher in ripe mango peels respectively.

Berardini *et al*. (2005a) studied that the content and the degree of esterification of mango peel pectins range from 12-21 % and from 56-66 %, respectively. More over, mango peel is rich source of flavonol O- and xanthone C-glycosides, gallotannins and benzophenone derivatives (Berardini *et al*., 2005b; Schieber *et al*., 2003; Berardini *et al*., 2005a).

2.8 Bread

According to Food Act 1983 (ACT 281) and Regulations, “bread” means the product obtained by baking a yeast-leavened dough prepared from flour or meal; or a combination of these with water and yeast and may contain any other food. Bread shall not contain more than 45 % of water or moisture in any part of the loaf (Pyler, 1973). Bread may contain propionic acid and sodium, potassium or calcium salts, not exceeding 2,000 mg/kg of bread as permitted preservative, while permitted food conditioner should not exceed 2,500 mg/kg of wheat flour or meal used and permitted colouring substances.

Breads can be prepared by baking, steaming or frying the dough which consist of flour and water. Salt is used in most of bread making process and usually a leavening agent such as yeast is used. Other ingredients such as fat, emulsifiers, sugars and dough conditioner could be added to improve the dough and bread quality. Each of these ingredients has its own function in bread and a slight change in the amount applied will alter the final bread quality. Therefore, a proper balance of ingredients is needed to obtain high-quality bread. A loaf of bread usually contain 57.00 % flour, 36.00 % water, 1.60 % sugar, 1.60 % fat or shortening, 1.00 % milk powder, 1.00 % salts, 0.80 % yeast, 0.80 % malt and 0.20 % mineral salts. According to Federal Standard for baking product (21 CFR 136), the weight of a bun should be less than half a pound per unit while bread would usually weight more than half a pound.

Bread products are well accepted worldwide because of the low cost, ease of preparation, versatility, sensory attributes and nutritional properties. Hence, bread has been reported to be one of the dietary staple diet for the world's population (Ahlborn *et al.*, 2005; Fardet *et al.*, 2006). Bread in human nutrition is not only a source of energy, but also a supplier of irreplaceable nutrients for the human body. It provides little fat, but high quantities of starch and dietary fibre as well as cereal protein. Apart from that, bread contains the B group vitamins and minerals which are mostly magnesium, calcium and iron (Isserliyska *et al.*, 2001). There are many methods for bread making but basically it was categorized into 3 group, straight dough, sponge dough and continuous dough.

2.8.1 Types of bread

Generally, bread making is different in each country based on the types of bread and the human population culture. The consumer demands have resulted in a variable of style, shape and taste of different breads. Few factors can differentiate one kind of bread to the other such as the inner structure, processing technique, equipment used and controlling mechanism. Owens (2001) has divided the overall bread into four categories:

1. Pan bread

This product is produced by placing the dough into metal pan for proofing and baking. Normally square or round shapes pan are used. Bread pans with cover lid result in better shaping effects. Examples of pan bread are sandwich and 'open top'.

2. Free standing bread

This type of dough is proof and baked without using any mould. It is meant to enable the dough spread freely during proofing and baking. Examples of this group of bread are 'coburgs' and 'bloomers'.

3. Baguettes, Parisien and other long shaped bread products.

4. Roll bread and small bread which are fermented by mould. This type of bread is normally high in sugar and fats. Hence, these breads are sweeter and softer in taste.

2.9 Ingredients of bread making

2.9.1 Bread flour

Bread flour obtained from hard wheat which is coarse and gritty (Charley and Weaver, 1998). The breads produced from bread flour are superior in grain, texture and volumes. It is also suitable in making yeast breads. Hard wheat flour with excellent gluten quality and high protein content contributed to the good dough characteristic that has high water adsorption with high resistance and extensibility to stretching (Hung *et a*l., 2005). Goesaert *et al*. (2005) stated that wheat flour is the major ingredient in bread making. It consists mainly of starch, water and proteins which are important in the structure and properties of breads. Wheat flour has the ability to form viscoelastic dough when the particles were hydrated (Hoseney, 1991). Mechanical properties of dough are important in handling the properties of the dough and quality of baked goods (Bollain *et al*., 2006).

Starch is present as distinct semi-crystallize granules in the dough. Starch act as inner filler in the continuous protein matrix of the dough and can absorb up to 46 % of water during dough preparation (Goesaert *et al*., 2005). The starch granules gelatinize and swell during baking. The major constituents in starch are amylose and amylopectin. The solubilized amylose shall form a continuous network which swelled and deformed the starch granules which are embedded and interlinked (Goesaert *et al*., 2005). Amylose plays an important role in determining the initial loaf firmness because of the rapid retrogradation properties (Eliasson and Larsson, 1993). It also contributes to the staling effect during bread storage. Bread staling will result in to crumb firming, changed in flavours and moistened crust (Ribottaa and Le Bail, 2007). Staling is often associated with interactions between starch molecules and gluten proteins (Martin *et al*., 1991).

The formation of the dough involved disaggregating the protein particles, hydrating the protein to form gluten and spreading the gluten over the surface of the free starch to form a continuous matrix (Farrand, 1972). The gluten in wheat flour results in the viscoelastic properties of the formed dough (Autran, 1993). Sufficient gluten must be formed to cover the surface of the starch for gas retention (Pyler, 1973). About 80 % of the total protein of wheat flour is gluten. Gluten proteins are composed of gliadins and glutenins which are responsible for extensibility (viscosity) and strength (elasticity) of the bread dough. The gluten in the wheat flour provides unusual properties which are suitable properties for bread making (Goesaert *et al*., 2005).

During dough mixing, the wheat flour is hydrated and gluten protein is disrupted due to the mechanical energy input. Gluten proteins are transformed into a continuous cohesive viscoelastic gluten protein network (Singh and MacRitchie, 2001). The resistance of the dough increases during mixing and reaches a peak before finally decreases as a result of over-mixing. The further changes occurred in gluten protein network during dough fermentation and play a major role in retaining the carbon dioxide produced during fermentation and the initial stages of baking. Gas retaining properties is significant in the determining loaf volume and the crumb structure of the bread.

Equilibrium between the dough viscosity and elasticity is required for quality in bread making. One of the important factors which contributed to the quality in bread making is the gliadin/glutenin ratio of the gluten proteins. Glutenin polymers are larger and therefore formed a continuous network which provides strength (resistance to deformation) and elasticity to the dough (Ewart, 1972; Belton, 1999). However, gliadins act as plasticisers of the glutenin polymeric system which provide plasticity/viscosity to wheat flour doughs (Cornec *et al*., 1994).

2.9.2 Composite flour and benefit

Initially, composite flour refers to a mixture of wheat, cereal and legume flours used in the production of baked products (Dendy and Dobraszczyk, 2001). However, the term ‘composite flour’ has now been broaden to as a mixture of non-wheat flours, roots and tubers, legumes or other raw materials (Dendy and Dobraszczyk, 2001). In 1964, Food and Agriculture Organization of the United Nations had launched the ‘Composite Flour Program’. The purpose of this program was to seek the potential of raw materials in the application of bakery products (FAO, 1971).

Application of composite flour provides two different functions. Firstly, the application of composite flour is to enrich the nutritional characteristics of products and secondly to lower the use of imported wheat by partially or total substitution. The reduction of imported wheat used in bread making shall favour the economy of non-wheat producing countries. Hence, the high expenditure of imported wheat could be lowered and controlled besides promoting the use of locally grown grains (Hugo *et al.,* 2003). Thus, many researchers had studied on other starch sources to substitute wheat, such as corn, barley, cassava and cowpea (Bushuk and Hulse, 1974; Kawka *et al*., 1997; Defloor and Delcour, 1993b; Almazan, 1990; Hallen *et al*., 2004; Mbofung *et al.*, 2002).

De Ruiter, (1978) reported that optimal nutritive value with good processing characteristics is a necessity in composite flours. Research on composite flour utilization in cereal based products such as bread, biscuit, pasta and snack foods have been well accepted (Habib, 2004**)**. More over, the addition of non-wheat flour will increase the nutritive value of the flour mixture and hence will elevate the market value of composite flours (De Ruiter, 1978). Sharma *et al*. (1999) also suggested the supplementation of wheat flour with inexpensive staples such as cereals and pulses in improving the nutritional quality of wheat products. Oshodi *et al.* (1999) reported that breadnut flour contains high quality protein with total essential amino acid of 55.10 %, which was comparable with soy flour and egg. Pumpkin and canola seed flour increased the protein, lysine and mineral contents of the breads by 11-38 %, 90-200 % and 70-135 %, respectively as reported by Mansour *et al.* (1999). Hugo *et al.*, (2003) reported that bread made with boiled malt flour (30 %) had an improved crumb structure, crumb softness, water-holding capacity and resistance to staling, as well as a fine malt flavour as compared to bread made with grain sorghum flour.

According to Dendy and Dobraszczyk (2001), composite flours would alter the physical characteristics of the end product. The application of composite flours in baked goods will result in different baking quality and sensory properties. For example, the utilization of sweet potato gives natural colourant that may be favourable for bakery products (Collado *et al.*, 1997). However, total or partial substitution of wheat for non-wheat composite flour would result in undesirable baking characteristics especially in bread. The loss of gluten due to the reduction in wheat flour used will lead to lower bread making potential as the viscoelastic properties of composite flour dough has reduced (Khalil *et al*., 2000).

2.9.3 Water

Water plays an essential role in starch gelatinization, yeast and enzyme inactivation as well as attributing flavour and colour formation during baking of dough (Czuchajowska *et al*., 1988). The main water adsorbing components in the dough are water soluble protein (pentosans), bran, gluten-forming proteins and starch (Cauvain and Young, 2000). Optimum water level is important during the process of baking to give a desirable structure of the bakery product. Dough high in water content will produce a low viscosity and soft dough, which it will affect the shape and hence failure in retaining the loaf shape during proofing (Cauvain and Young, 2000). On the other hand, low water content in the dough resulted in high viscosity and resulted in stiffer dough. It is difficult to change the shape of stiff dough during the processing of bread making.

During baking, starch is gelatinized and proteins are denatured. These two phenomena contributed to the formation of crumb in the dough (Marston and Wannan, 1976). Denaturation of proteins released the water while gelatinization of the starches absorbs the water. Water losses resulted in the gluten proteins to lose its extensibility and the matrix become permeable to vapours and liquids (Cauvain and Young, 2000). The permeable matrix formed the structure of the crumb and crust. Higher moisture loss on the surface of the loaf contributed to the formation of crispy and porous crust due to the evaporation effect at high baking temperature (Cauvain and Young, 2000). Browning of the crust and bread aroma is the result from Maillard reactions which also affected by the water content (Skjoldebrand, 1986).

Bread has the highest moisture content of all baked product. The baked crumb consist higher moisture content as compared to the crust. This characteristic is essential to develop a crispy crust and soft crumb (Cauvain and Young, 2000). Pomeranz (1985) proposed that moisture distribution and water content can influence the shelf life of bread resulted by staling. Staling resulted in the loss of crust crispness, firmness in crumb, changes in moisture content, taste and aroma of the bread. The migration of the moisture from the crumb to the crust surface caused the crumb to be firmer and the softer crust.

2.9.4 Yeast

Yeasts are essential living microorganisms in the production of bread (Baleiras-Couto *et al.*, 1996; Deak and Beuchat, 1996). It is a natural leavening agent used to make the dough rise. The optimal conditions for the yeast to grow require warmth, moist and nutrients in order to initiate fermentation. Fermentation occurred when the yeast metabolize the sugar to produce CO_2 and alcohol. The release of CO_2 gas resulted in the leavening action in yeast breads. The advantage of yeast leavening is in the characteristic taste and aroma of the baked product. El-Dash and Johnson (1970) proposed that yeast is a potential source to produce primary amino groups in bread dough.