PHYSICO-CHEMICAL AND SENSORY CHARACTERISTICS OF MUFFIN SUBSTITUTED WITH DIFFERENT LEVELS OF MANGO PULP FLOUR

by

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CIRI-CIRI FIZIKO-KIMIA DAN SENSORI MUFIN YANG DIGANTIKAN DENGAN BEBERAPA ARAS TEPUNG MANGGA.

ABSTRAK

Paras tepung mangga yang berbeza (5%, 10%, 15% dan 20%) ditambah ke dalam mufin untuk menggantikan tepung gandum dan menentukan kesannya ke atas fiziko-kimia dan penilaian sensori mufin. Fiziko-kimia dan sifat berfungsi isi mangga (FMP) dan tepung isi mangga (MPF) juga ditentukan. Keputusan menunjukkan bahawa isi mangga dan MPF merupakan sumber karbohidrat, gentian, kanji rintang, mineral dan kebolehan penampungan kapasiti air yang baik. Penambahan MPF (5-20%) ke dalam mufin telah meningkatkan kandungan lembapan, lemak, gentian kasar dan abu secara signifikan ($p<0.05$) tetapi mengurangkan kandungan protein, karbohidrat dan nilai kalori secara signifikan ($p<0.05$). Kedua-dua FMP dan MPF didapati tinggi kandungan kalium. Keputusan menunjukkan MPF meningkatkan kandungan kalium secara signifikan ($p<0.05$) dalam mufin. Isi mangga mempunyai gentian tak larut (IDF) yang tinggi berbanding gentian larut (SDF). Nilai IDF, SDF dan TDF (jumlah gentian larut) menunjukkan peningkatan signifikan ($p<0.05$) dengan penambahan paras MPF ke dalam mufin. Mufin mengandungi 4.93-7.19% TDF, 3.69-4.91% IDF dan 1.24-2.28% SDF. Isi mangga mengandungi 15.30% kanji rintang (RS) tetapi menurun sehingga 13.72% dalam MPF. Penambahan MPF tidak meningkatkan kandungan kanji rintang (RS) (1.89-2.51%) dalam mufin. Isi mangga mengandungi 4.27% fruktosa, 2.90% glukosa dan 0.39% sukrosa. Nilai kandungan fruktosa, glukosa dan sukrosa dalam MPF masing-masing adalah 2.70%, 1.45% dan 0.14%. Penambahan MPF meningkatkan kandungan fruktosa, glukosa dan sukrosa dalam mufin. Asid sitrik adalah asid organik utama dalam isi mangga, tepung dan mufin. Kandungan kanji meningkat secara signifikan ($p<0.05$) dalam MPF. Penambahan MPF dalam mufin menurunkan kandungan kanji secara signifikan ($p<0.05$). Isi mangga mengandungi 65.84 mg/g jumlah kandungan fenolik dan 4.87 µg/mg GAE dalam tindak balas radikal DPPH tetapi kedua-dua nilainya menurun dalam MPF. Penentuan glisemik indek (GI) menunjukkan nilai GI menurun secara signifikan ($p<0.05$) dengan penambahan MPF ke dalam mufin. Semua mufin ini dianggap rendah-GI memandangkan nilainya dibawah 55. Mikrostruktur SEM sebelum dan selepas tindakan haba menunjukkan granul kanji dan vakul gas dalam pelbagai saiz dan bentuk. Isipadu lof (161-150 ml), isipadu spesifik (2.92-2.54 cm^3) dan ketinggian (5.20-4.30 cm) didapati berkurang apabila ditambah dengan MPF pada paras yang berbeza. Peningkatan paras MPF menurunkan kekerasan, kegaman, kekenyalan dan warna kulit mufin. Jangka hayat mufin adalah selama 4 hari memandangkan nilai keselamatan untuk yis dan kulapuk adalah 1000 ‘cfu’/g mufin.

PHYSICO-CHEMICAL AND SENSORY CHARACTERISTICS OF MUFFIN SUBSTITUTED WITH DIFFERENT LEVELS OF MANGO PULP FLOUR

ABSTRACT

Different levels of green mango pulp flour (5%, 10%, 15% and 20%) were substituted for wheat flour into muffins and evaluated for the physical and sensory properties. Physico-chemical and functional properties of the fresh mango pulp (FMP) and mango pulp flour (MPF) was also investigated. Result indicated that FMP and MPF are good sources of carbohydrate, dietary fibre, resistant starch, mineral and water holding capacity. Substitution of MPF (5-20%) in muffin significantly increased ($p<0.05$) the moisture, fat, crude fibre and ash content but significantly decreased ($p<0.05$) the protein, carbohydrate and caloric value. Results showed that potassium were high in FMP and MPF. Hence, the addition of MPF significantly increased ($p<0.05$) the potassium in muffins. The FMP has more insoluble dietary fibre (IDF) than soluble dietary fibre (SDF). Result indicated that IDF, SDF and TDF (total dietary fibre) increased significantly ($p<0.05$) with the increasing level of MPF in muffin. Muffin contained of 4.93-7.19% TDF, 3.69-4.91% IDF and 1.24-2.28% SDF. The FMP contained 15.30% resistant starch (RS) but reduced to 13.72% in MPF. Addition of MPF in muffin did not significantly increased ($p>0.05$) the RS content (1.89-2.51%). The FMP contained 4.27% fructose, 2.90% glucose and 0.39% sucrose. The amount of fructose, glucose and sucrose in MPF is

2.70%, 1.45% and 0.14%, respectively. The addition of MPF increased the fructose, glucose and sucrose content in muffin significantly ($p<0.05$). Citric acid is the major organic acid in FMP, MPF and muffins. Processing of FMP into flour increased the total starch content in MPF. Incorporation of MPF in muffin decreased the total starch content significantly ($p<0.05$). The FMP consist of 65.84 mg/g total phenolic content and 4.87 µg/mg GAE in the scavenging DPPH radical activity but both values decreased in MPF. Glycemic index (GI) determination showed that the GI value significantly decreased ($p<0.05$) with ultimate increased in MPF in muffin. These muffins are considered as low-GI food as the GI values of all muffins were below 55. SEM microstructure showed the occurrence of various sizes and shape of starch and gas vacuole before and after heat treatment. The loaf volume (161-150 ml), specific volume (2.92-2.54 cm^3) and height (5.20-4.30 cm) were found to decrease with increasing level of MPF. Increasing level of MPF decreased the hardness, gumminess, chewiness and crumb colour. The 15% MPF muffin scored the highest in the overall acceptability of muffin. Shelf life of the muffins was 4 days as the safety limit for yeast and mold is 1000 cfu/g muffin.

CHAPTER 1
INTRODUCTION

The mango (*Mangifera indica* L.) has been reported to be originated from India (Vivekananthan *et al*., 2004). Mango has been widely cultivated and became an essential fruit crop in South East Asia particularly in the Philippines, Indonesia, Thailand, Myanmar (Burma) and Malaysia. Today, mango has been recognized to be a potential commercial fruit and was exported to countries like Egypt, South East Africa, South Africa, USA (Hawaii and Florida), West Indies, Israel, and Australia (Vivekananthan *et al*., 2004).

Mango fruit is a drupe with variable size and shape, depending on the species and variety. It has evolved to over 500 varieties, with 350 propagated from commercial nurseries. Mangoes, unlike other fruits differ not only in physical appearance but also in their aroma and flavour. Skin of the ripen mango fruit is green to yellow or red while the flesh is pale yellow to orange in colour. The intensity of such characteristics varies widely amongst varieties upon ripening. Ueda *et al*. (2001) reported that the changes in surface colour in 'Chiin Hwang No. 1'cultivar differed from the 'Irwin' variety during maturity, but the changes in flesh colour during maturation ripening were similar between the two cultivars.

Some fine examples of mangoes are 'Purple Irwin' and 'Red Irwin', 'Manila', 'Caraboa' and 'Pico' from Philippines, 'Julie' from the West Indies, 'Golek' from Indonesia, 'Haden' from Hawaii and 'Kengsington Pride' from

Queensland, Australia. Some mango varieties cultivated in Malaysia are Chokanan, Harumanis, Nam Dork Mai and Maha. The Chokanan variety is said to be juicier and sweeter than other varieties (Agri-Food Business Development Centre, 2006; Mitra and Baldwin, 1997).

Mango is remarkably high in carotenoid content, the yellow to orange colour of ripe mango flesh provides a high pro-vitamin A value and antioxidative capacity. Pott *et al*. (2003) states that β-carotene is generally the predominant carotenoid, comprising 48–84% of the total carotenoid concentrations. More over, mango also consist a fair amount of insoluble dietary fibre and soluble dietary fibre (Ramulu and Rao, 2003). Besides being appreciated as fresh fruit, mango is also used as an ingredient in processed products such as in dairy products, fruit salads, ice-cream and snacks (Giraldo *et al*., 2003; Mitra and Baldwin, 1997 Cooke *et al*., 1976; Subramanyam *et al*., 1975).

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. Mangoes were consumed all year round in Southeast Asia. The supplies of mangoes come from India, Pakistan, Indonesia, Thailand, Malaysia, Philippines, Australia and South Africa (Agri-Food Business Development Centre, 2006). In 1999, Malaysia produced 50, 000 metric tonne of mangoes to be exported to the Southeast Asia market (Agri-Food Business Development Centre, 2006).

In Asia, mango is an important tropical and subtropical fruit and is commonly preserved in the dried form. However, consumers preferred fresh mangoes over the preserved dried form of processed mangoes. This reason has attributed to the lost of huge quantities of fresh mango fruit during commercialization (Vergara-Valencia *et al*., 2007). The lost of mango fruit during commercialization is due to the fact that mango is a climacteric fruit which has a very short shelf life (Rathore *et al*., 2007). Mango fruit reached its respiration peak of ripening process at ambient temperature on the third and fourth day after harvesting (Narayana *et al*., 1996). Nevertheless, mango is still scarcely commercialized as compared to the quantity produced due to the difficulties in the post harvest management in the producing countries (Giraldo *et al*., 2003). Inadequate infrastructure and pest quarantines have further limited its export to global mango trade.

The lack of adequate storage facilities is another factor that attributes to the lost of this mango agriculture produce. The mango fruit could only be stored for a relatively short time as the ripening process peaks on the third and fourth day as reported by Narayana *et al*. (1996). As the mango fruit is a highly perishable fruit, longer storing time would lead this fruit to over-ripening and thus spoilage (Vazquez-Salinas and Lakshminarayana, 1985).

The export of mango products contributes significantly to the fruit sector of the mango producing countries in South East Asia such as Philippines, Indonesia, Thailand, Myanmar (Burma) and Malaysia. Besides, the countries in

Asia are the major exporters of processed tropical and subtropical fruit products (International Tropical Fruits Network, 2005). The drying of mango fruit is resorted as an alternative in order to address the storage problem, shelf life of the mango fruit as well as to ease the man-handling process during commercialization. However, Durance *et al*. (1999) reported that conventionally dried mangoes have undesirable tough texture, poor colour and cooked flavour with reduction in nutritive value. These poor characteristics of dried mango product would reduce its economic value in the food industry. Hence, further research for suitable mango processing to improve or replace the conventionally dried mangoes is needed in order retain the product freshness characteristics. Furthermore, a stable product which could lengthens the shelf life in the market, would be a convenient way to increase commercialization in the non-producing countries (Giraldo *et al*., 2003).

Extensive studies have been done on the development of mango products. These studies involve development of juice, chutney, jam, dried mango slices and even incorporation of mango powder into bakery products (Giraldo *et al*., 2003; Vijayanand *et al*., 2000; Larrauri *et al*., 1996; Mir and Nath, 1995; Heikal *et al*., 1972). Production of mango in powder or flour form has great economical potential as it offers convenience since mango flour has reduced bulk weight and better storage stability.

In 1964, the Food and Agriculture Organization of the United Nations (FAO) has launched a 'Composite Flour Program' in Rome, Italy. The program's main objective was to seek new potential of raw materials for the replacement of wheat usage in bread, biscuits, pastas and other similar flour based products (De Ruiter, 1978). Composite flours are actually the blends of wheat and other flours. Dendy (2001) noted that flours made from maize, sorghum, barley, oats, cassava, potato, yams and root crops were the usual composition of non-wheat flour in composite flours. This composite mixture must result in comparable characteristic similar to wheat. By this way, the composite flour mixture will gain popularity as it is higher in nutritive value as compared to wheat flours (De Ruiter, 1978). Consequently, the market value for composite flours is elevated and thus the demand for non-wheat flours will accelerate.

Implementing the composite flour into traditional wheat-based food products shall give additional nutrients from non-wheat materials and hence increased the nutritive value of the wheat-based products (De Ruiter, 1978). Composite flours caused changes in functional and physical characteristic (Mansour *et al*., 1999; Ptitchkina *et al*., 1998; De Ruiter, 1978). The composite flour could attribute in favourable or undesirable changes in the functional and physical characteristics of baked products. Thus, researches on the incorporation of composite flour into baked products needs to be further studied in improve physical and sensory characteristics.

Cereal grains are frequently used in confectionary as a source of dietary fibre. However, according to Figuerola *et al*. (2005), fruit fibre has better quality and higher fibre content. They also stated that fruit fibre has higher water and oil holding with lower caloric value as compared to cereal grains. Suitable fruit fibre processing shall minimize the losses of nutrient compounds which in return exert higher health promoting effects (Larrauri, 1999). The beneficial health promoting effects from fruit fibre has led to an increasing interest in fruit fibres. Fruit fibres has been proven to be rich in soluble dietary fibre and fibres containing associated compounds (carotenes, tocopherols, flavonoids) with health promoting abilities (Giraldo *et al*., 2003; Larrauri, 1999).

According to World Health Report (2002), an estimation of 31% of heart disease, 11% of stroke worldwide and 19% of gastrointestinal cancer were contributed due to low intake of fruit and vegetables. Medical intervention usually centers on diet modification and drug therapy to lower elevated blood cholesterol, a risk factor in heart disease.

Consumption of foods high in polyunsaturated fat in daily diet has resulted significantly positive health effect for several decades now (Ranhotra *et al*., 1990). Wang *et al*. (2002) further elaborated that world-like health authorities had recommended a decrease in the consumption of animal fats and protein and increase the source of dietary fibre. The best recommendation for a healthy population suggests an intake of 25-30 g of total dietary fibre of very diverse types of fibre sources. This recommended amount should contribute to the decrease of the incidence such as diabetes, obesity and cardiovascular diseases (Guillon and Champ, 2000). Guillon and Champ (2000) studies had also shown that dietary fibre can reduce risk of colon cancer, has significant cardiovascular benefit and prevent obesity. Since people have begun to understand that a healthy digestive system has an impact on overall health, it is essential to include fibre food in our everyday life. The processing and development of fibre enriched foods would help human population to meet the recommended dietary allowance for fibres.

Functional foods are maintaining an important role as a matter of convenience while being the primary source of nutritional enhancement with dietary supplements (International Food Information Council Foundation, 2007). While the attributes of many traditional functional foods are being discovered, new food products are being developed with beneficial components. Besides, appealing traditional products that are already common in daily diets incorporated with nutritional ingredients are being created to capture consumer interest. Bakery product such as muffin is a good example product being incorporated with nutritional ingredients. More over, muffins are often preferred as a daily food choice served as breakfast or snack (Sultan, 1983). Various types of functional additives as well as new types of raw ingredients can be added to enhance the quality of muffin.

Muffins tend to be less sweet in the earlier version and much less varied in ingredients as they are meant to be useful breakfast as it is quick and easily baked.

In modern practice, it almost has a topping baked-in favourite like blueberries and chocolate chips. Healthy muffin recipes were evolving rapidly. More over, the utilization of wheat in muffins is well extended. Research has been done on muffins regarding the physicochemical effects from supplementing with whole full-fat flaxseed meal and flaxseed oil (Shearer and Davies, 2005); the effect of thermal processing on purple wheat bran (Li *et al*., 2007) and the physical properties and physiological effects of cereal β-glucan (Lazaridou and Biliaderis, 2007). Although studies on muffins are extensive, Mialon *et al*. (2002) stressed that there is a need to increase studies on healthy muffins with extended shelf life without artificial preservatives and reduction in sugar and fat content.

Thus, the primary aim of this study is to evaluate the effects of mango pulp (*Mangifera indica* var. Chokanan) in flour in muffins. The specific objectives were;

1. To determine the chemical and functional attributes of the fresh mango pulp (FMP) and mango pulp flour (MPF)
2. To evaluate the effects of partial substitution of MPF to wheat flour at different substitution level in terms of chemical, physical and sensory properties of muffin
3. To investigate the microstructure of FMP and MPF and the effect of heat treatment on the microstructure of muffins with different substitution level of MPF in muffins

CHAPTER 2
LITERATURE REVIEW

2.1 Background of *Mangifera indica*

Family: Anacardiaceae

Genus: *Mangifera*

Species: *Mangifera 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

Mango is a tall evergreen tropical tree growing up 30-100 feet tall with a dense, heavy crown. The mango tree is long-lived; some specimens are more than 250 years old and are still fruit bearing. Mango, in English and Spanish, or manja in Dutch has a great variety in species, forms, size, colour, scent, taste and quality. There are over 500 named varieties of the mango.

Mango has been grown in India for the last six thousand years. Since then, it has become an essential fruit crop in South East Asia— the Philippines, Indonesia, Thailand, Myanmar (Burma) and Malaysia. Other countries like Egypt, South East Africa, South Africa, USA (Hawaii and Florida), West Indies, Israel, and tropical Australia has prioritized mangoes as an important fruit crop (Vivekananthan *et al*., 2004).

In the year 1999, the fruits yield from mango crops amounted to 40% of the total tropical fruit production in the world. The producing countries are India, China and Mexico and Philippines (Giraldo *et al*., 2003). Mango is also one of the most important non-citrus fruits grown in Cuba (25,000 t/year) and these amount of mango fruits processed by the fruit industry represented 30% of the total non-citrus fruits produced in Cuba (Larrauri *et al*., 1996).

Mango is a popular fruit among the people in Asia, particularly in India. It is considered as one of the quality fruits in the international market attributed by the delicious taste and high caloric value. The importance of mangoes as essential fruit crop is reflected by its position in the world fruit market (Giraldo *et al*., 2003; Larrauri *et al*., 1996). Mangoes rank fifth in terms of amount in production, and is placed as second among the tropical fruits.

Countries in Asia are the major exporters of mangoes. In 1999, India was the major mango producing country in supplying the mango demands in Southeast Asia. This figure is followed by Pakistan and Philippines as shown in Table 2.1. Other supplies of mangoes exported to Southeast Asia are Indonesia, Thailand, Australia, South Africa and Malaysia (Agri-Food Business Development Centre, 2006).

Table 2.1: Countries producing mangoes for Southeast Asia market in 1999.

Country	Production (Metric Tonne)
India	12 000 000
Pakistan	937 705
Indonesia	53 452
Thailand	91 241
Malaysia	**50 000**
Philippines	931 500
Australia	51 389
South Africa	115 152

Source: Agri-Food Business Development Centre, 2006

In year 2000 to 2003, the export value of fresh mangoes valued between RM5-9 million per year (Agri-Food Business Development Centre, 2006). Singapore was the major export market for fresh Malaysian mangoes, which accounts for 75-85% of the total export value as shown in Table 2.2. Other countries like Brunei, Indonesia and Hong Kong are the minor importers of mangoes produced in Malaysia.

Table 2.2: Destinations export for fresh mangoes from Malaysia.

Country	Year 2000		Year 2001		Year 2002		Year 2003	
	Metric tonne	RM ('000)	Metric tonne	RM ('000)	Metric tonne	RM ('000)	Metric tonne	RM ('000)
Singapore	2168.00	3922.90	3466.00	7465.30	2999.00	6140.20	1975.00	4081.60
Brunei	639.00	1279.30	778.00	1535.20	398.00	750.00	23347.00	580.50
Indonesia	6.00	20.80	26.00	49.60	102.00	207.50	805.00	524.00
Hong Kong	2.00	6.70	28.00	38.70	1.00	8.90	13.00	53.40
USA	-	-	1.00	2.90	3.00	8.60	7.00	39.50
Others	16.00	29.40	30.00	167.60	13.00	98.90	25.00	105.10
Total	2831.00	5259.10	4329.00	9259.50	3516.00	7214.10	26172.00	5384.10

Source: Agri-Food Business Development Centre, 2006

The genus *Mangifera* consists of 69 species and is mostly restricted to tropical Asia. The highest diversity occurs in Malaysia, particularly in Peninsular Malaysia, Borneo and Sumatra representing the heart of the distribution range of the genus. Maximum species diversity exists in western Malaysia and about 28 species are found in this region (Agri-Food Business Development Centre, 2006). In Malaysia, Perak, Perlis, Kedah and Melaka are the main states cultivating mangoes as well as smaller areas in other states. The varieties available in Malaysia are the Chokanan, Harumanis, Nam Dork Mai, Maha and many more. The Chokanan variety is said to be juicier and sweeter than other varieties (Agri-Food Business Development Centre, 2006). Table 2.3 shows three types of Malaysia mangoes fruit characteristics. The Chokanan variety mango was observed to have firm with slightly fibrous texture besides having sweet and aromatic taste.

Table 2.3: Types of Malaysia mangoes fruit characteristics.

Variety	Shape	Size (g)	Colour	Total soluble solids	Fruit texture and taste
Chokanan	Oblong	250-350	Golden colour skin with yellowish orange coloured flesh	16-17%	Firm, slightly fibrous, sweet and aromatic
Harumanis	Ovate oblong	350-550	Dark green skin withyellow blush on shoulder and yellowish orange coloured flesh	16-17%	Fine, sweet and aromatic
Masmuda	Ovate oblong	400-500	Yellow skin and flesh	14-15%	Firm, fine, sweet with slight aroma

Source: Agri-Food Business Development Centre, 2006

2.1.1 Nutritional value of *Mangifera*

A whole fresh mango is composed of 33–85% of the edible pulp, 7–24% of the peel and 9–40% of the kernel (Wu *et al*., 1993). Mangoes are good sources of nutrient in food as it provides essential minerals and vitamins as shown in Table 2.4.

Table 2.4: Average value of nutrition components of fresh mango pulp (FMP) per 100 gram.

Component	Per 100 gm edible portion
Food energy	234.00 KCal
Moisture	84.12 g
Protein	0.39 g
Fat	0.02 g
Carbohydrate	15.05 g
Fibre	0.40 g
Ash	0.40 g
Calcium	8.00 mg
Phosphorous	15.00 mg
Iron	0.16 mg
Sodium	7.00 mg
Potassium	159.00 mg
Vitamin B1	0.05 mg
Vitamin B2	0.07 mg
Niacin	0.30 mg
Vitamin C	15.10 mg

Source: Agri-Food Business Development Centre, 2006

Mangoes is remarkably high in carotenoid content, which is responsible for the yellow to orange colour of ripe mango flesh, provides a high pro-vitamin A value and antioxidative capacity. Total carotenoid concentrations are usually in the range of 0.90–9.20 mg/100 g whereas the 'Kent' showed exceptionally high values of up to 11 mg/100 g (Pott *et al*., 2003). The author also stated that generally β-carotene is the predominant carotenoid, comprising of 48–84% of the total carotenoid concentrations. The β-carotene content has shown to be promising as cancer-preventing agents (Reddy and Reddy, 2005). Carotene also acts as antioxidants as well as vitamin A precursors (Handelman, 2001). Besides carotene, ascorbic acid and dietary fibre is also found in mangoes especially unripe mango fruit. Hence, green mango fruit is a source of antioxidant and dietary fibre (Vergara-Valencia *et al.*, 2007; Hymavathi and Khader, 2005).

Lipid composition in mango has been studied by Pott *et al*. (2003). The authors investigated the biochemical changes during acetylene-induced ripening in the cultivar 'Alphonso' and found that C16:0, C16:1 and C18:1 was 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, which is an acidic polysaccharide, is found in high concentrations in mango pulp and the yield, degree of esterification and gel strength of the product depend on the type of raw material used (variety, conditions of processing) and the extraction process (Iagher *et al*., 2002). Ramulu and Rao (2003) reported that mangoes consist of 2 g/100 g of total dietary fibre and the moisture content was 79.90 g/100 g.

The by-products in fruit processing industries like the seeds and peels are discarded as waste (Srirangarajan and Shrikhande, 1979). These by-products of peels and seeds represent 35-60% of the total mango fruit weight, depending on cultivars (Subramanyam *et al*., 1975). The peel and stone proportions in mango fruit range from 20-30% and 10-30%, respectively. These wastes are usually turned into animal feeds, although more valuable products can also be obtained (Larrauri *et al*., 1996).

The peel and seed of mangoes are rich in various nutrients and many value added products could be obtained from them. Juice, wine, vinegar and good quality pectin have been produced from peels (Larrauri *et al*., 1996). Mango kernel contains high amount of fat and starch. The oil extracted from kernel is of good quality and could be used in cosmetic and soap industries. The kernel flour (starch) after mixing with wheat or maize flour is used in chapaties (Anand and Maini, 1997). About 10% alcohol could be obtained from mango kernel by co-culture fermentation. In food processing industries, various enzymes are invariably used for pulp liquefaction and juice clarification. Enzymes such as cellulase and pectinase from mango peel and amylase from mango kernel could be produced by microbial fermentation (Anand and Maini, 1997).

2.1.2 Mango products

Fruit products utilizing the mango pulp can be converted into jam, nectar, chutney, fruit bars and jellies. Iagher *et al*. (2002) studied the rheology of the mango pulp and noted that the mango pulp is highly viscous and exhibit pseudoplasticity property.

Mangoes had been credited as one of the fine quality tropical fruits attributed by its extraordinary flavour, texture and colour. These characteristics had made mangoes special not only for fresh consumption but also as an ingredient in confectionaries. Hence, processed mango products that exhibit good stability and quality would create an opportunity of commercialization in non-producing countries (Giraldo *et al*., 2003).

Mango bar is the most popular fruit bar in India (Vijayanand *et al*., 2000). Mango bar is traditionally prepared by adding cane sugar with the ratio of 1:2 or 1:4 to ripe mango puree. These puree mixtures are spread on bamboo mats and dried in the sun. Layers of puree are added after the previous one has dried. These sun dried products are then cut into uniform sizes and packaged with cellophane film to be commercialized.

The traditional process of sun drying was improved by mechanizing the fruit pulp extraction, blending and drying of the mango puree in a hot air drier. Stainless steel trays substituted the traditional bamboo mat and the mango purees was dried in a hot air drier at 50-60ºC for a period of 18 to 22 h. The mango bar produced using this process had better consumer acceptability for colour, texture and overall quality properties. The mechanical processed product was preferred compared to the sun dried product as the sun-dried product is discoloured and the process is unhygienic and lengthy. More over, cabinet drying resulted into a product with better colour and flavour (Mir and Nath, 1995; Heikal *et al*., 1972). The type of mango used as well as the consistency of the purees was reported to have a definite effect on the quality of the mango bar (Vijayanand *et al*., 2000).

Mango bar has very low protein content (1–2%) as reported by Pramanik and Sengupta (1978). Protein content has been increased by adding soy protein isolate and rice flour, whey protein isolate and shrimp flour (Chauhan *et al*., 1998; Exama and Lacroix, 1989; Payumo *et al*., 1981).

Solar drying of the mango products is a relevant way of tackling the issue of lack of adequate storage facilities. Natural solar drying is still widely practiced in order to preserve their productions. However, this traditional method has proved inefficient as it was being implemented under unsanitary conditions and produces only a very limited number of products. Reviews on ways of improving the quality of the naturally dried products using natural solar drying needed to be further studied as reported by Toure´ and Kibangu-Nkembo (2004).

Mango bars was reported to be a hygroscopic product resulted by high sugar content (Mir and Nath, 1995). Hygroscopicity means the ability of the food to absorb moisture from high relative humidity environment (Jaya and Das, 2004).

Absorption of moisture from the external atmosphere and non-enzymic browning are the main problems during storage (Rao and Roy, 1980). Therefore, proper drying and adequate packaging are essential for maintaining their quality. Water activity influences product stability and its physical characteristics such as texture (Mir and Nath, 1995).

However, drying process of sugar-rich mango pulp into powder is difficult, mainly because of the low molecular weight sugars such as fructose, glucose, sucrose and citric acid present in the pulp (Jagtiani *et al*., 1988). These mango pulps powder are very hygroscopic in their amorphous state and loose the free flowing nature at high moisture content (Jaya and Das, 2004).

2.1.3 Problems associated with mango production

Mango processing maintains the mango product freshness characteristics, stabilized the nutritional values from depleting and thus lengthening the shelf life in the market. Mango products with extended shelf life would ease commercialization of the product in non-producing countries (Giraldo *et al*., 2003).

The post harvest process for the fresh mangoes is complicate as it is difficult to maintain the quality and quantity of the mangoes (Tefera *et al*., 2007). Agricultural produce is lost every year due to lack of adequate storage facilities. For fruits like mango, the percentage of waste is much higher. Larrauri *et al.* (1996) reported that 25-50% of mango yield is lost due to post harvest management. If proper methods of harvesting, handling, transportation and storage are adopted, such losses could be minimized (Giraldo *et al*., 2003).

Mangoes are generally harvested at physiological maturity stage and ripened (Lakshminarayana *et al*., 1970). Fruits are hand-picked or plucked with a harvester. During harvesting, the latex trickles down the fruit surface from the point of detachment imparting a shabby appearance to it upon storage (Lakshminarayana, 1980).

During storage, bruised and injured fruits lead to the development of brown and black spots resulting in undesirable physical appearance. More over, abrasions on the peel or to the stalk end resulted in the infection of microorganism and thus lead to the rotting of the fruits. Thus, mango fruits are harvested with an intact of 8-10 mm long of the stalks to prevent undesired spots on the fruit skin caused by sap burn (Lakshminarayana, 1980). Fruits are reported to have less prone stem-end rot and other storage diseases when it is harvested with an intact stalk (Subramanyam *et al*., 1975).

Storage of the mangoes below room temperature after post harvest is essential for extending the consumption period of fruits and regulating their supply to the market. However, some variety of mangoes can be kept at room temperature for about 4-10 days (Mitra and Baldwin, 1997; Subramanyam *et al*., 1975).

Chemical treatments and low storage temperature shall extend the shelf life of mangoes (Lazan and Ali, 1993). The harvested fruits are pre-cooled and stored at 10-12ºC. The fruits could be kept in good condition for 3-4 weeks at these low temperatures. At low temperature, the problem of chilling injury can be overcome by keeping the mango fruits in 0.50% ventilated polythene bags. It is a general practice to harvest mango fruits early in the season (premature stage) to capture an early market (Mitra and Baldwin, 1997). Without any ripening aid, these mango fruits do not ripe uniformly. Mangoes could be ripened uniformly by dipping in 750 ppm ethrel (1.80 ml/litre) in hot water at $52 \pm 2^{\circ}$C for 5 minutes and could be kept 4-8 days under ambient conditions. Matured mango fruits can similarly be ripened with lower doses of ethrel for the development of uniformity in colour appearance.

2.2 Composite flour

De Ruiter (1978) reported that the Food and Agriculture Organization of the United Nations (FAO) launched a 'Composite Flour Program' in 1964 in Rome, Italy. The program's objective is to seek new possibilities for raw materials other than wheat for bread, biscuits, pastas and similar flour base production. This move corresponds to the increasing consumption of bread throughout the world as well as with the availability of bread in developing country (Dendy, 2001). Production of wheat has not been sufficient to satisfy human needs in bread consumption (Khalil *et al*., 2000). The use of composite flours would ensure the sufficiency of flours to be used in bread making (Dendy, 2001). The application of composite flours plays a role in lowering or substituting the use of wheat. Hence, the high expenditure of imported wheat could be lowered and controlled besides elevating the use of locally grown grains (Hugo *et al.*, 2003). It should be noted that composite flours serve the functions of lowering or removing the use of wheat or other staple for economic reasons.

Composite flours are actually blends of wheat and non-wheat flours. Efforts have been systematically undertaken to replace part of the wheat flour by other starch sources (Khalil *et al*., 2000). The formulation of mixed flours consists mainly of indigenous raw ingredients with a composition that combines optimal nutritive value with good processing characteristics is a necessity in composite flours (De Ruiter, 1978). Researched on composite flours published were mainly from maize, sorghum, barley and oats, cassava, potato, yams and root crops (Dendy, 2001). Flours produced from maize, barley and cassava were among the most predominant studied sources for the production of composite flour breads (Khalil *et al*., 2000).

Addition of different nutrients which originated from non-wheat flour will increase the nutritive value of the flour mixture and hence elevated the market value of composite flours (De Ruiter, 1978). 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. The addition of pumpkin and canola seed flour increased the protein, lysine and mineral (calcium. potassium, copper, iron and magnesium) contents of the breads by 11-38%, 90-200% and 70-135%, respectively (Mansour *et al.*, 1999).

Dhingra and Jood (2001) stated that wheat is considered nutritionally poor due to lacking in essential amino acids such as lysine and threonine. Grain and legumes could contribute significantly in nutritional value such as protein, mineral and B-complex vitamins required for the people in developing countries (Dhingra and Jood, 2001). Sharma *et al*. (1999) also suggested that the supplementation of wheat flour with cereals and pulses will improved the nutritional quality of wheat products. Dhingra and Jood (2001) had also studied on supplementation of wheat flour with soybean and barley flours in bread development. They noted that barley flour has high concentration of β-glucans while soybean flour has high protein, fat and lysine contents.

However, the application of composite flours alters the physical characteristics of the end product (Dendy, 2001). Application of composite flours in baked goods will result in different baking quality and sensory properties. Sweet potato flours vary widely in colour such as orange, yellow and purple colour which resulted in natural colourant favourable for bakery products (Collado *et al*., 1997). Several problems were associated with the partial or total substitution of wheat in the production of baked goods especially bread. For example, the loss of gluten due to the reduction in wheat flour used will lead to lower bread making potential due to the reduction in viscoelastic properties of composite flour dough (Khalil *et al*., 2000). The viscoelastic properties of composite flour dough could be resolved by implementing low pH in the dough. It was shown that low pH of fermented sorghum flour inactivated amylases and increased the viscosity of sorghum flour which thus improved the gas-holding capacity of sorghum and wheat composite dough (Hugo *et al.,* 2003). It was noted by Hugo *et al.,* (2003) 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. Therefore, further research need to be carried out in order to produce satisfactory baked goods from composite flour.

2.3 Quick bread and Muffin

A quick bread is a type of leavened bread with chemical leaveners such as baking powder or sodium bicarbonate. Breads made from chemical leaveners were relatively reliable and quick unlike yeast breads which often take hours to rise and depend on external factors such as temperature.

Quick-bread products are commonly served in many hotels and restaurant (Sultan, 1983). The qualities of quick bread are easily affected by the ingredients used in baking. Varieties of hot breads and quick breads are usually served at meals as appetizers. Quick bread has gain popularity since muffins, biscuits, corn sticks, scones and similar quick bread varieties provide satisfying satiety (Sultan, 1983).

Muffin is categorized in the quick bread family. Muffin is made from a mixture of sifted flour, egg, milk, sugar, salt and baking powder. Muffins are usually baked in the form and size of a cupcake. The crust of muffin is crispy, shiny, pebbly and golden brown in colour with a well rounded top (Sultan, 1983). The interior of the crumbs are soft, moist, light and tender with no tunneling.

There are two types of muffins. One is a yeast leavened muffin and the other type is raised by addition of baking powder or baking soda. The yeast raised muffin was the first to be encountered in Britain around 11th century A.D (Wikipedia, 2008).

In the 19th century, the invention and use of baking powder has shortened the baking process of muffins. Thus, muffins baked with baking powder have been termed as 'quick' muffin. Typical muffin is about 8 cm in diameter and resembled a flat bun. Muffin started out as a form of small cake, or possibly an adaptation of cornbread. However, muffins are less sweet as compared to cupcakes. In the earlier centuries, muffins were baked with lesser variety of ingredients. Muffins were usually made as breakfast as it is quick and easily baked. It is beneficial to be served as breakfast since muffins are able to provide minerals, vitamins and dietary fibres. High fibre carbohydrate-rich breakfast has been shown to augment satiety and reduce daily energy consumption as compared with fat-rich breakfast (Cho *et al*., 2003; Mattes, 2002; Holt *et al*., 1999; Ruxton and Kirk, 1997).

Muffin was first baked in lozenge shaped pan and later changed into circular shapes. Muffins easily staled characteristic is a hindrance from being marketable as baked good. In the middle of 20th century, packaged muffin was