EFFECT OF YOUNG CORN (*Zea mays* L.) POWDER INCORPORATION IN BISCUITS AND MUFFINS ON PHYSICOCHEMICAL PROPERTIES, SENSORIAL ACCEPTABILITY AND GLYCEMIC INDEX VALUES

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by

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LIST OF SYMBOL AND ABBREVIATION

ANOVA	Analysis of variance
BMI	Body mass index
CI	Confidence interval
Cm	centimeter
CV	Coefficient of variation
G	gram
GI	Glycemic index
iAUC	Incremental area under curve
Kg	kilogram
Mm	millimeter
N	Newton
SD	Standard deviation
SEM	Standard error of mean
YCP	Young corn powder

KESAN PENAMBAHAN SERBUK JAGUNG MUDA (*Zea mays* L.) DALAM BISKUT DAN MUFIN TERHADAP CIRI-CIRI FIZIKOKIMIA, PENERIMAAN SENSORI DAN NILAI INDEKS GLISEMIK

ABSTRAK

Kajian ini dijalankan untuk membangunkan biskut dan mufin yang ditambah serbuk jagung muda (YCP) dan menilai kesannya ke atas komposisi pemakanan, profil tekstur menggunakan instrumen, penerimaan sensori dan nilai indeks glisemik. Jagung muda segar dikeringkan, dikisar menjadi serbuk dan ditambah ke dalam formulasi biskut dan mufin pada kadar 0, 10, 20 dan 30%. Keputusan kajian mendapati penambahan YCP ke dalam biskut dan mufin meningkatkan kandungan protein dan serat dietari secara signifikan. Analisis fizikal ke atas biskut menunjukkan tiada perbezaan yang signifikan dari segi ciri kekerasan dan keupayaan patah dengan peningkatan peratus YCP berbanding dengan biskut kawalan. Diameter bagi biskut tanpa YCP dengan biskut yang ditambah YCP juga tiada perbezaan statistik yang signifikan. Kesan penambahan YCP ke atas nisbah sebaran biskut hanya signifikan pada kadar 30% penambahan. Sementara itu, pada mufin, penambahan YCP tidak meningkatkan kekerasan secara signifikan pada kadar 10 dan 20%. Kekenyalan mufin dengan penambahan YCP sehingga 20% tidak berbeza secara signifikan berbanding mufin kawalan. Tekstur mufin yang ditambah YCP juga didapati mudah lerai berbanding mufin tanpa YCP. Daya kunyah mufin tidak dipengaruhi secara ketara oleh YCP. Ujian penerimaan sensori menunjukkan skor purata untuk aroma, ciri luaran, kerapuhan dan perisa biskut yang ditambah 10% YCP adalah lebih baik daripada biskut tanpa YCP. Mufin yang diformulasi dengan YCP, tanpa dipengaruhi kadar penambahan, mendapat skor penerimaan yang lebih baik dari segi ciri luaran, tekstur, rasa dan perisa berbanding mufin tanpa YCP. Berdasarkan keputusan yang didapati dari ujian penerimaan sensori, dua formulasi biskut (0 dan 10% YCP) dan dua formulasi mufin (0 dan 30% YCP) telah dipilih untuk ujian penentuan nilai indeks glisemik (GI). Nilai GI bagi biskut dengan penambahan 10% YCP ialah 46 ± 11 sementara bagi biskut tanpa penambahan YCP ialah 61 ± 13. Mufin dengan penambahan 0 dan 30% YCP pula masing-masing mencatatkan nilai GI 58 ± 6 dan 57 ± 9. Penambahan YCP menurunkan nilai GI biskut dan mufin dan merendahkan secara signifikan puncak lengkung tindak balas glukosa plasma selepas makan. Keputusan kajian ini menunjukkan bahawa biskut dan mufin yang ditambah YCP mempunyai nilai GI rendah dan sederhana dengan sifat fizikokimia yang boleh diterima.

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ABSTRACT

This study was conducted to develop biscuits and muffins incorporated with young corn powder (YCP) and to evaluate the effect on nutritional compositions, instrumental texture profile, sensorial acceptability and glycemic index (GI). Fresh young corn was dried, ground into powder and added in biscuit and muffin formulations at concentrations of 0, 10, 20 and 30%. Results showed incorporation of YCP in biscuits and muffins had significantly increased protein and total dietary fiber contents. Physical analysis of biscuits demonstrated that there were no significant differences in hardness and fracturability attributes as the level of YCP incorporation increased. There was no statistically significant difference ($p>0.05$) in diameter between biscuits with YCP and biscuits without YCP. Influences of YCP on spread ratio of biscuits were significant only at 30% level of incorporation. Meanwhile, for muffins, incorporation of YCP did not significantly increase the hardness at level of 10 and 20%. Springiness of muffins with up to 20% level of YCP incorporation did not differ significantly from 0% YCP muffins. It was noted that muffins with YCP was less cohesive than muffins without YCP, which indicates that the former was better than the latter. Chewiness of muffins was not substantially affected by YCP. Sensory acceptability test revealed that the mean score for aroma, appearance, crispiness and flavour of biscuits added with 10% YCP was better than biscuits without YCP. In addition, muffins formulated with YCP, regardless of level of incorporation, received better acceptability score for appearance, texture, taste and flavour compared to muffins without YCP. Based on sensorial acceptability results, two formulations of biscuits (0 and 10% YCP) and two formulations of muffins (0 and 30% YCP) were selected for GI testing. It was found that the GI of biscuits with 10% YCP was 46 ± 11 while the 0% YCP biscuits was 61 ± 13. Muffins with 0 and 30% YCP recorded GI values of 58 ± 6 and 57 ± 9, respectively. Addition of YCP had reduced the GI values of biscuits and muffins and significantly reduced the postprandial peak glucose responses. The results of this study showed that biscuits and muffins added with YCP have a low and intermediate GI with acceptable physicochemical properties.

CHAPTER 1

INTRODUCTION

1.1 General introduction

Bakery products include biscuits, muffins, cakes, breads, pastries and pies. They contain significant amount of flours which are mixed with various other ingredients and ultimately undergo dry-heating process in a baking oven (Cauvain and Young, 2007). Biscuit is a small, crisp and dry baked product. Muffin is a type of quick-bread commonly served during breakfast or teatime. In Malaysia, consumption of bakery products, particularly biscuits and breads, appeared in the list of top ten daily consumed foods based on the Malaysian Adult Nutrition Survey (Norimah *et al.*, 2008). Possible reasons for such wide popularity are broad range of choices, easy availability and convenient to be enjoyed as a snack. However, as for Malaysia, the use of wheat flour as one of the major ingredients in bakery products is quite challenging because wheat is totally being imported. Increasing demand for wheat-based products will definitely increase importation of wheat flour. For that reason, searching for other local source of alternative ingredient to partially substitute wheat flour in bakery products would give many advantages as it could reduce dependence on wheat while at the same time could significantly save foreign exchange. In the meantime, manipulating the ingredients used in bakery products preparation by replacing the refined wheat flour with potentially nutritive ingredients would also be beneficial to improve the nutritional quality of the bakery products since majority of them are high in carbohydrate, fat and calorie, but low in fiber contents (Mishra and Chandra, 2012). The refining process of wheat flour had eliminated the natural dietary fiber and various important vitamins and minerals, thus downgrading the nutritional quality of the end products.

Carbohydrate is known as main nutritional composition in bakery products. Dietary carbohydrate has direct and greater influence on postprandial blood glucose than other components of the diet, like protein and fat (Sheard *et al.*, 2004). Foods rich in carbohydrate can be categorized according to the glycemic index (GI) concept which is based on the physiological response (postprandial glycemia) produced by the carbohydrate. The concept was firstly coined by Jenkins *et al.* (1981). GI is defined as 'the incremental area under the blood glucose response curve of a 50 g available carbohydrate portion of a test food expressed as percent of the response to the same amount of carbohydrate from a reference food consumed by the same subject' (FAO/WHO, 1998). It was previously shown that low GI diet was beneficial in reducing risks and complications of various health conditions like diabetes (Salmeron *et al.*, 1997a), cardiovascular diseases (Barclay *et al.*, 2008) and cancers (Augustin *et al.*, 2003; Gnagnarella *et al.*, 2008). GI value of food or meals is affected by addition of dietary fiber (Hodge *et al.*, 2004; Schulze *et al.*, 2004). Trowell (1976) described dietary fiber as 'portion of food that is derived from cellular walls of plants which resist hydrolysis by digestive enzymes of human'. It improves glycemic response by reducing rate of glucose absorption in small intestine (Cherbut *et al.*, 1994). In a local study, Ng *et al.* (2010) reported that mean dietary fiber intake of Malaysians was 10.7 to 16.1 g/day, which did not meet the national recommendation of 20–30 g/day (RNI, 2005). Other than wholegrain, fruits and vegetables are widely known as sources of dietary fiber. However, fruits and vegetables consumption is still below recommendation of five servings a day, particularly in low- and middle-income populations (Hall *et al.*, 2009). In addition, recent findings by Yen and Tan (2012) showed that daily consumption of vegetables in Malaysia was significantly lower in diabetics than non-diabetics.

Young corn is a common vegetable found in Asian cuisines. It is the finger-length ear of corn (*Zea mays*) which appears yellow in colour. It is a unique product of corn since the harvested part is the immature female inflorescence rather than the mature plant or ear (Hallauer, 2001). Young corn is usually hand-picked prior to fertilization and before or just after the emergence of the silk. The dehusked and desilked young corn is often enjoyed due to its crispiness and sweet, juicy and delicious taste. In spite of being freshly consumed on most occasions, young corn is also available as frozen or canned, particularly for export purposes. Nutrients in young corn are comparable with other vegetables like cauliflower, cabbage, tomato, eggplant and cucumber (Yodpet, 1979; Anitha and Rajyalakshmi, 2005). Other than being nutritious, it is also free from pesticides because the cob is tightly protected in its husk (Chutkaew and Paroda, 1994). However, corn production particularly in Malaysia focuses mainly on the mature corn. As a result, young corn becomes an agricultural waste. It is partly utilized whereby people normally consume young corn in stir-fried or mixed vegetables dishes. Sometimes, they just throw it away if they do not have enough workforces to manually hand-pick the young corn.

This waste could potentially turn into healthy ingredient as the significant amount of dietary fiber in young corn could be beneficial to encourage intake among Malaysians. Furthermore, common sources of dietary fiber added in bakery products such as oat, barley and atta flour are imported. There are also not many studies which have identified high-fiber edible flour that can replace the imported wheat flour. In addition, there were no prior studies done to determine the effect of young corn in processed foods specifically in bakery-based products. There are also limited findings on incorporation of locally available high fiber young corn as a potential diabetic-friendly ingredient in development of therapeutic food products.

1.2 Objectives

1.2.1 General objective

The present study aimed to investigate changes in physicochemical properties, sensory acceptability and glycemic index (GI) values of biscuits and muffins incorporated with young corn powder (YCP).

1.2.3 Specific objectives

This study was conducted with the following specific objectives:

1. To formulate biscuits and muffins incorporated with YCP;
2. To determine the nutritional compositions and texture profiles of biscuits and muffins incorporated with YCP;
3. To evaluate the sensory acceptability of biscuits and muffins incorporated with YCP; and
4. To determine the glycemic index (GI) of biscuits and muffins incorporated with YCP.

CHAPTER 2

LITERATURE REVIEW

2.1 Young corn

Corn or maize is a member of grass family *Poaceae* (*Gramineae*) and scientifically known as *Zea mays* L. The height of a mature corn plant is about 8 feet (United States Department of Agriculture, 2013). Its stem resembles a bamboo with several internodes. Leaves grow from each internode. Ears of corn usually grow between the stem and leaf sheath at the midsection of the plant. The ears are the female inflorescence and they are tightly protected in several layers of husk. A corn plant may have several ear shoots but usually only the topmost ear is successfully fertilized. The unfertilized ear will remain as young corn and will not grow into mature corn. It is harvested when the silk is not emerged or slightly emerged. If the ears are harvested later, they become hard and their qualities deteriorate.

Several other names that were given to refer the young corn are baby corn, cornlettes and candle corn. The dehusked young corn is often eaten as a vegetable. It can be eaten raw as salad, cooked in soup, sautéed or stir-fried with other vegetables. The ideal size of a young corn is 2–4 inch long and ⅓ – ⅔ inch in diameter of base (Miles and Zenz, 2000). The weight of edible young corn ear was approximately 13% of the ear with the husk. Young corn is a valuable and attractive product in the market. Generally, consumers prefer young corn with creamy to light yellow colour. The demand for young corn is high due to its delicate flavour and crispiness. It is a unique product of corn since the harvested part is the immature female inflorescence rather than the mature plant or ear (Hallauer, 2001).

2.1.1 Consumption of young corn

Statistical information on production of young corn is limited probably due to negligence of many producing countries in reporting their productions or they just consider together with sweet corn production. Export of young corn is dominated by Thailand which accounted for 80% of the world trade volume of fresh and canned young corn. In 2004, around 31.2% of Thailand total young corn export volume went to USA (Johnson *et al.*, 2008). Production and market of young corn are expanding globally especially in Asia, South-America and Africa. In Malaysia, young corn cultivation is one of the prominent activities by local farmers which occupied 6,390 hectare of farming area. Its annual yield in year 2010 is around 36,420 metric tonne or MYR118 million in value (Anon, 2011).

2.1.2 Nutritional values of young corn

Vitamins and minerals in young corn were reported to be comparable with cauliflower, cabbage, tomato, eggplant and cucumber (Yodpet, 1979). According to Yodpet (1979), young corn contained 28 mg calcium, 86 mg phosphorus, 64 IU vitamins, 0.05 mg thiamine, 0.08 mg riboflavin, 11 mg ascorbic acid and 0.03 mg niacin. Recently, a study done by Hooda and Kawatra (2013) also support the previous finding by Yodpet (1979) whereby young corn provides various key nutrients like protein (18.0%) and dietary fiber (27.1%). Starch content in young corn was 15.6% (Hooda and Kawatra, 2013). Other than being nutritious, young corn is also free from residual effects of pesticides since the young cob is tightly protected in its husk (Chutkaew and Paroda, 1994).

2.1.3 Processing of young corn

Processing of young corn by freezing and canning techniques are widely applied to enhance the storage life especially for export purposes. Vegetables like young corn that contain significant amount of moisture are highly perishable. Canned young corn is commonly preserved in brine and packed in metal cans or glass jars. Young corn preserved in glass jars is a specialty item and more expensive than metal canned young corn. About 90% of the total production of young corn with size 108 oz is produced as canned young corn for export. Most of the smaller size young corn is sold domestically in Thailand. Other technique for preserving young corn is freezing. Hooda and Kawatra (2012) demonstrated that some minerals like calcium, iron, magnesium and zinc significantly reduced during freezing. In addition, frozen young corn for export is costly than other processed product of young corn.

2.1.4 Young corn dietary fiber as raw ingredient in food products

Presently the method of preparation or preservation of young corn only focus on certain processing techniques such as freezing, bottling or canning, as mentioned in Section 2.1.3. Meanwhile, in culinary, young corn is often prepared by blanching, stir-frying or mixing with other vegetables in soup. However, the effort of utilizing young corn in form of flour or young corn powder as raw ingredient in food products had never been explored or studied previously. To the best of our knowledge, there is no report has been published or documented on the utilization of young corn dietary fiber as raw ingredient, particularly in bakery-based items which can potentially enhance the nutritional quality of the food products.

2.2 Trend of fruits and vegetables intake

In many populations around the world, intake of fruits and vegetables are less than WHO recommendation of 400 g or 5 servings per day. It is estimated that around 1.7 million deaths throughout the world are caused by inadequate intake of fruits and vegetables. Consuming sufficient amount of fruits and vegetables can reduce the risk for cardiovascular diseases, stomach cancer and colorectal cancer. There are growing evidences showing that obesity are contributed by consumption of energy-dense processed foods which contain more fat and sugars than nutrient-dense foods such as fruits and vegetables (WHO, 2011).

According to the recent Malaysian Dietary Guidelines (2010), 3 servings of vegetables and 2 servings of fruits a day is recommended as part of a balanced diet (Ministry of Health Malaysia, 2010). However, majority of Malaysians are not following the recommended guidelines since they are consuming fruits and vegetables less than other staple foods such as rice and meat. Statistical figure from the United Nation Food and Agriculture Organization (FAO) which indicated that from 1980 to 2003, Malaysians on average consumed only 150 g of fruits and 78 g of vegetables daily (Yen and Tan, 2012).

Several factors have been identified in relation to low intake of fruits and vegetables. Income, gender and culture can affect fruits and vegetables consumption. A study reported that people with higher income had higher amount of fruits and vegetables intake than those with lower income, possibly due to affordability issue (Yen and Tan, 2012). Meanwhile, females usually consume more fruits and vegetables than males who often consumes meat (Prättälä *et al.*, 2007). In Malaysia, cultural influences on fruits and vegetables intake were more prominent among

Chinese and Indians compared to Malays (Ismail *et al.*, 2013). Chinese food culture believes in the Yin and Yang elements while Indian practises vegetarianism. Malays who are Muslims are free to consume any fruits and vegetables. This could be the reason to greater consumption of fruits and vegetables among Malays than Chinese and Indians as reported by Nurul Izzah *et al.* (2012).

In the food pyramid, fruits and vegetables are located at the second level which indicates that they are crucial in daily diet particularly as a primary source of dietary fiber besides whole grains. Dietary fiber is defined by Trowell (1976) as "portion of food that is derived from cellular walls of plants which resist hydrolysis by digestive enzymes of human". It is known to be important mainly for gastrointestinal and cardiovascular health. The Malaysian Recommended Nutrient Intake (RNI) for dietary fiber is 20–30 g per day for all age groups (NCCFN, 2005). In addition, fruits and vegetables are also rich in bioactive compounds such as phytochemicals. Liu (2003) suggested that the potent antioxidant and anticancer activities of fruits and vegetables are due to the additive and synergistic effects of phytochemicals found in them. Therefore, we are encouraged to consume variety of fruits and vegetables to get as much nutrients as possible. Furthermore, fruits and vegetables are low in energy density.

2.3 Drying of foods

Preservation of various foods is required in order to minimize or prevent spoilage, to ensure their availability throughout the year, to keep the desired levels of nutritional properties for the longest possible life span and to use as value added products (Jangam and Mujumdar, 2010). Out of these, the main reason for applying food preservation techniques is spoilage. Mechanical, physical, chemical or microbial damage during handling can lead to spoilage or deterioration of foods. Among these, chemical and microbial damages are most common causes (Rahman, 2007). Storage conditions and moisture level in the product will influence the microbial growth. The rates of microbial growth differ among microorganisms and depending on the conditions. During processing and storage of foods, several chemical and enzymatic changes such as browning could occur, resulting in loss of sensorial properties and nutritional qualities of the food products, thus jeopardizing the acceptability of processed foods for human consumption.

Freezing, vacuum packing, canning, preserving in syrup, food irradiation, adding preservatives and drying which is the most popular dehydration are widely employed methods for food preservation. Canning and freezing are better at retaining the taste, appearance and nutritive value of fresh food. It is said that drying will never replace canning and freezing. However, for the purpose of adding variety to meals and providing delicious and nutritious snacks, drying seems to be an excellent method of preservation. Moreover, another advantage is that dried foods also require much less storage space compared to canned or frozen foods. Drying involves removal of moisture by application of heat and it is one of the most cost-effective ways of preserving foods (Jangam and Mujumdar, 2010).

Foods which are commonly preserved by using drying technique are marine-based products, meat products, fruits and vegetables. Moisture content in the products can be as high as 90% or greater which needs to be reduced to an acceptable level in order to keep away from microbial growth. There are different ways of drying steps undergone by different types of food products. Some products may require pre- and post-processing steps other than specific type of dryer to obtain satisfaction on the result of drying. The importance of pre- and post-processing steps is primarily to reduce drying load and to develop products with better quality. Examples of pre-processing steps are blanching, salting and soaking. Both coating and packaging are crucial as post-processing steps. Besides that, selecting a proper dryer which is suitable for drying a particular product can be a complex step as well because there are numerous dryers available (Chen and Mujumdar, 2009).

2.4 Utilization of vegetable powder in bakery products

Dried vegetables can further be processed into powder and incorporated in flour-based products such as bakery products, pasta and noodles. Utilizations of various composite flours to partially replace wheat flour in bakery products are widely reported in the literature. The composite flours came from various sources like fruits by-products (Ajila *et al.*, 2008; Rupasinghe *et al.*, 2008a), plant seeds (Atuonwu and Akobundu, 2010; Rajiv *et al.*, 2012), legumes (Noor Aziah *et al.*, 2012) and non-wheat grains such as millet, amaranth and rye (Oliete *et al.*, 2010; Rajiv *et al.*, 2011; Sanz-Penella *et al.*, 2013). Incorporation of composite flour in bakery products can positively or negatively affect the nutritional compositions, organoleptic acceptability as well as the texture profiles.

Incorporation of vegetables powder in bakery products may improve the nutritional quality. Nutritional compositions such as protein and dietary fiber of biscuits increased with addition of amaranth leaves powder (Singh *et al.*, 2009). Amaranth leaf is a green, leavy vegetables commonly found in Indian cuisines and it was reported to be rich in β-carotene and ascorbic acid as well as other minerals such as calcium, iron and zinc (Shukla *et al.*, 2006). Besides that, other finding by Turksoy *et al.* (2011) that uses other vegetables, i.e. pumpkin and carrot pomace powder in cookies also found significant increase in dietary fiber.

Study by Mastromatteo *et al.* (2012) found that the use of several vegetable flours such as carrot, artichoke, pumpkin, broccoli, spinach, asparagus, yellow pepper and few others in durum wheat functional bread affected the organoleptic properties at different degree depending on the type of vegetable flour. Among the tested vegetables, yellow pepper flour at 10% addition in the bread was found to give the best results for sensory evaluation. On the other hand, sensory evaluation by experts revealed that cake added with 30% sunroot powder to partially replace wheat flour were more favourable than control (Gedrovica *et al.*, 2010).

Differences in physicochemical and starch granular properties of composite flour used in the formulation can contribute to the variation in physical characteristics of the cookies. Singh *et al.* (2003) reported that addition of potato and corn flours in cookies produced different effect on the hardness, spread factor and colour characteristics due to difference in swelling behaviour and melting of starch crystallites in corn and potato flours. Meanwhile, addition of cruciferous vegetables like broccoli powder was reported to significantly increase the spread factor in cookies (Lee and Sung, 2010).

2.5 Bakery products

Biscuits, muffins, bread, rolls, pies and pastries are common products on the bakery shelves. Cauvain and Young (2007) defined bakery products as "foods manufactured from recipes largely based on or containing significant quantities of wheat or other cereal flours which are blended with other ingredients. They are formed into distinctive shapes and undergo a heat-processing step which involves the removal of moisture in an oven located in a bakery". Flour is the main ingredient in most bakery products formulations. It is usually made from wheat. Bakery products prepared with wheat flour is often referred as standard against bakery products made with non-wheat flour. Wheat flour contains protein composite known as gluten which is essential for texture development especially in bread-making. Whole wheat flours are produced using the entire kernel while white flours are made only from the endosperm, without bran and germ. Bran and germ contain substantial amount of dietary fiber, iron, fatty acids and vitamin B. Yet, white flours or refined flours constitute 97% of total flour consumed (Charley and Weaver, 1998).

Bakery products are routinely consumed and appreciated around the globe. They are enjoyed by peoples of various age groups during snack times or special occasions other than as part of their meals. According to Malaysian Adult Nutrition Survey 2006 which involved 6,742 subjects all over Malaysia, bread and biscuits appeared in list of top ten most commonly consumed foods (Norimah *et al.*, 2008). Due to their high popularity, bakery products can be chosen as suitable carriers to deliver some essential nutrients. There are ongoing studies being done to identify nutritive ingredients which can be incorporated as partial replacement for refined wheat flour in order to improve the nutritional quality of bakery products.

2.5.1 Biscuits

'Biscuit' is an English term used to describe a product that is hard-eating, sweetened and thin with low moisture and long shelf-life which is commonly enjoyed as a snack. Meanwhile, Baking Industry Research Trust (2010) described biscuit as "baked product that has a cereal base, e.g. wheat, oat or barley of at least 60% and low moisture content of 1−5%, excluding moisture content from fillings and icings". Nevertheless, the US biscuit refers to a sweetened product of intermediate moisture, usually eaten during breakfast together with savoury foods. The UK biscuit is almost similar to the US cookie while the US biscuit is closer to a UK scone. To add more perplexity, the term *biskuit* in French refers to a dry-eating, sponge-type cake with an aerated structure that has low moisture and long-shelf-life. The closest UK product to the French *biskuit* is sponge cake, despite its higher moisture content (Cauvain and Young, 2007).

In general, fat content and energy in biscuit are usually higher and shelf-life of biscuit is also much longer compared to other baked products. The extended, mould-free shelf-life of biscuits, up to several months, could be attributed to the low moisture content and low water activity of the product. Furthermore, biscuits also have prolonged organoleptic shelf-life because it is not prone to problem such as staling and losing of moisture if properly stored in air-tight containers. Besides that, biscuits also have many differences from other classes of baked products, most notably, in term of their size and weight. The products in biscuits group usually weigh less than 100 g which is commonly around 15−16 g. Biscuits and cookies typically appear thin and round or rectangular in shape while their thickness are commonly less than 10 mm thick (Cauvain and Young, 2007).

2.5.2 Muffins

Muffin is a type of quick bread originated from America and it is baked in portions appropriate for one person in cups or cases. Quick breads are flour-based baked products that do not rely on microorganisms such as yeast to leaven them by producing carbon dioxide. In the preparation of quick breads, flour is combined with liquid in particular ratios to form batter with a required consistency. For popovers and cream puffs, pour batters which have a ratio of liquid to flour of 1:1 are needed. Pour batters are thin and easy to pour. Meanwhile, as for muffins, drop batters which are thicker than pour batters are required. Drop batters have 2 parts flour and 1 part fluid (Charley and Weaver, 1998). However, English muffins are totally different from common muffins. English muffins are flat rounds of yeast-raised rolls that are produced in much the same way English crumpet (Wheat Foods Council, 2005). The texture is chewy with some air pockets. English muffins are commonly cooked on a griddle rather than being baked in an oven.

Muffin cups or cases are commonly round sheets of paper, foil, or silicone with scallop-pressed edges that will give the muffin a round cup shape. In the baking of muffins, they are needed to line the bottoms of muffin tins as well as to aid removal of the finished muffin from the tin. There are differences between muffins and cupcakes. Muffins are relatively healthy because it is usually not too sweet and more likely to be loaded with fruits instead of candy. The texture is usually drier and slightly denser than cupcakes. Meanwhile, cupcakes are miniature cakes. Unlike muffins, they are sweet with various flavours and usually have frosting. A cupcake is tender and rich with eggs and butter. Cupcakes are dessert item and not an everyday breakfast food like muffins (Christensen, 2010).

2.6 Food compositions analysis

The determination of food composition is fundamental to theoretical and applied investigations in food science and technology and is often the basis of establishing the nutritional value and overall acceptance from the consumer standpoint. Proximate analysis is carried out to determine major components of food, i.e. moisture, ash, carbohydrates, lipids and proteins.

2.6.1 Moisture

Moisture determination can be one of the most vital analyses performed on a food product and yet one of the most challenging from which to obtain accurate and precise data. In addition, moisture content of foods varies greatly. According to Pomeranz and Meloan (2000), among common roots vegetables, radishes have the most (93%) and parsnips the least (79%), sweet potatoes contain less water (69%) than white potatoes (78%), green lima beans have about 67% and raw cucumbers over 96% water while dry legumes contain 10−12% water and the water content of commercially dried vegetables is preferably below 8%.

The dry matter that remains after removal of moisture is commonly referred to as total solids (Bradley, 2003). Moisture content has direct economic importance to the processor and the consumer because the amount of dry matter in a food is inversely related to the amount of moisture. Furthermore, moisture also affects the stability and quality of foods. Grains that contain excessive water is vulnerable to quick deterioration caused by mould growth, heating, insect damage and sprouting. An increase in moisture content lead to increase rate of browning of dehydrated vegetables and fruits. Therefore, moisture is a quality factor in the preservation of some products and affects stability in products such as egg powders, dehydrated vegetables and fruits, as well as other products like dried milks, dehydrated potatoes and spices and herbs. Other than that, moisture content is also important to the food processor as a quality factor for jams and jellies to prevent sugar crystallization. Reduced moisture is useful for convenience in packaging or shipping of concentrated milks, concentrated fruit juices and dehydrated products which are difficult to package if too high in moisture. Another importance of moisture assay is that the moisture content is often specified in compositional standards of a food product, for example, enriched flour must be ≤15% moisture and cheddar cheese must be ≤39% moisture. In addition, some calculations of the nutritional value of foods also require information on moisture content. Moisture data are used to indicate results of other analytical determinations on a dry weight basis (Bradley, 2003).

The procedures for moisture content determination stated in the food standards generally involve thermal drying methods. The sample is heated under carefully described conditions and the loss of weight is taken as a measure of the moisture content of the sample. The determination of moisture from the reduction of weight due to heating necessarily involves an empirical choice of the type of oven and the temperature and length of drying (Pomeranz and Meloan, 2000). Thus, the values obtained for moisture content depend on the randomly selected conditions where some of the methods provide approximate rather than accurate moisture values. Drying methods are simple, relatively rapid and allow the simultaneous analyses of many samples and continued to be the preferred procedures for moisture determination.

2.6.2 Ash

Ash is described as "the inorganic residue remaining after either ignition or complete oxidation of organic matter in a foodstuff" (Harbers and Nielsen, 2003). The nature of the food ignited and the method of ashing will determine the amount and composition of ash in a food product. In different foods, there are various minerals that compose the ash which occur in different proportions as well. Determination of ash in foods can be performed by weighing the dry mineral residue of organic materials after heating at elevated temperatures (550^{o}C). The usual procedure generally used to determine total ash is dry-ashing technique. The procedure is also used prior to an elemental analysis for individual minerals. In dry-ashing, the sample is weighed into a porcelain crucible and the organic matter is burned off without flaming and heated to constant weight. The residues of ashing are carbon-free. There are considerable difference in term of mineral constituents forms in ash and original food.

Determining ash content is essential for several reasons. It is a part of the proximate analysis for nutritional evaluation. The ash content of most fresh foods is less than 5% (USDA, 2011). Total ash content is a useful parameter to measure index of refinement of foods such as wheat flour or sugar. The ash test can fundamentally shows the separation of bran and germ from the rest of the wheat kernel because the mineral content of the bran is about 20 times that of the endosperm (Pomeranz and Meloan, 2000). In the preparation of a food sample for specific elemental analysis, the key step is ashing. Ash contents become important because certain foods are high in particular minerals. Elemental content from the ash of plant sources is variable although that of animal products is constant (Harbers and Nielsen, 2003).

2.6.3 Fat

The terms lipids, fats and oils are often used interchangeably. Lipids are defined as “a group of substances that, in general, are soluble in ether, chloroform, or other organic solvents but are sparingly soluble in water” (Min and Boff, 2003). The term lipid commonly refers to the broad, total collection of food molecule that meet the definition. Fats generally refer to those lipids that are solid at room temperature whereas oils generally refer to those lipids that are liquid at room temperature.

Lipids consist of a broad group of substances that have some common properties and compositional similarities. They were differentiated by general classification, i.e. simple lipids, compound lipids and derived lipids. Simple lipids include ester of fatty acids with alcohol, namely triacylglycerols and waxes. Compound lipids are phospholipids, cerebrosides and sphingolipids. Derived lipids are substances derived from neutral lipids or compound lipids, for example fatty acids, long chain alcohols, sterols, fat soluble vitamins and hydrocarbons. Triacylglycerols were the most prevalent class of lipids in the diet. They comprise of three fatty acids esterified to a glycerol molecule backbone.

The total lipid content of a food is usually carried out by organic solvent extraction method. Solvents which have a high solvent power for lipids and low or no solvent power for proteins, amino acids and carbohydrates are ideal for extraction. They also evaporate easily, have quite low boiling point and are non-flammable and non-toxic in both liquid and vapour states. Petroleum ether which composes of pentane and hexane is the low boiling point fraction of petroleum. It has a boiling point of 35–38^{o}C and is more hydrophobic lipids, cheaper, less hygroscopic and less flammable compared to ethyl ether (Min and Boff, 2003).

An accurate and precise quantitative analysis of lipids in foods is critical for accurate nutritional labelling, determination of whether the food meets the standard of identity and to ensure that the product meets manufacturing specifications. Inaccuracies in analysis may result in a product of undesirable quality and functionality, thus will add manufacturing cost. In bakery products, fat is important to give tenderness, provide a moister mouth feel, contribute structure, lubricate, incorporate air and transfer heat (Stauffer, 2005).

2.6.4 Protein

Proteins are an abundant component in all cells. Almost all except storage proteins are essentially required for biological functions and cell structure. Apart from their nutritional significance, proteins also affect the organoleptic properties of foods (Pomeranz and Meloan, 2000). Texture of foods from animal sources is controlled by protein. Meanwhile, wheat flour protein is considered one of the best indices of breadmaking quality. The protein content of foods has been determined on the basis of total nitrogen content since years ago because nitrogen is the most distinguishing element present in proteins. The Kjeldahl method has been widely employed to determine nitrogen content. Nitrogen content is then multiplied by a conversion factor to obtain protein content. By using this approach, it was assumed that dietary carbohydrates and fats do not contain nitrogen and that nearly all of the nitrogen in the diet present as amino acids in proteins (FAO, 2003). Based on early determinations, the average nitrogen (N) content of proteins was found to be about 16 percent, which led to use of the calculation N x 6.25, whereby 1/0.16 = 6.25, in order to convert nitrogen content into protein content.

In the Kjeldahl procedure, digestion of proteins and other organic components in a sample using sulfuric acid in the presence of catalysts convert the total organic nitrogen to ammonium sulfate. Then, neutralization of the digest with alkali takes place, followed by distillation into a boric acid solution that forms the borate anions. Next, the borate anions which are proportional to the amount of nitrogen are titrated with standardized acid. The result of the analysis shows the crude protein content of the food. This is because the nitrogen also comes from non-protein components. However, the content of non-protein nitrogen compounds is generally small than the protein content of most sound foods (Pomeranz and Meloan, 2000). Kjeldahl method is applicable to all types of foods, inexpensive if not using an automated system, accurate since it is an official method for crude protein content and has been modified to measure microgram quantities for proteins. Whereas some disadvantages include Kjeldahl method measures total organic nitrogen, not just protein nitrogen, is time consuming which requires at least 2 hours to complete, has poorer precision than biuret method and uses corrosive reagent like sulfuric acid.

Although protein consists of a complex mixture, most food analyst usually wants to find out the total protein content of a food. Now, total protein content of foods is determined empirically. An absolute method can be done by isolation and direct weighing of the protein. Such a method is completely impractical for food analysis but it is occasionally used in biochemical investigation. In addition, a "true protein" can be measured by summing up the amino acids which represents the protein content of the food (FAO, 2003). It is because proteins are made up of chains of amino acids joined by peptide bonds which can be hydrolysed to their component amino acids. Analysis of amino acids is performed by ion-exchange, gas-liquid or high-performance liquid chromatography (HPLC). However, this approach requires more sophisticated equipment than the Kjeldahl method and thus may be beyond the capacity of many laboratories, especially those that carry out only intermittent analyses. Furthermore, experience with the method is important; some amino acids (e.g. the sulphur-containing amino acids and tryptophan) are more difficult to determine than others. The advantage of this method is that it overcomes the problems with the use of total N x a conversion factor, thus requires no assumptions about either the non-protein nitrogen content of the food or the relative proportions of specific amino acids. In spite of the complexities of amino acid analysis, there has been reasonably good agreement among laboratories and methods.

2.6.5 Carbohydrate

Total carbohydrate can be measured by two principles, either by difference or by direct measurement of the individual components which are combined to give a total. Calculating carbohydrates by difference has been widely used. The protein, fat and ash and moisture content of a food are determined analytically, then being subtracted from the total weight of the food. The remainder, or difference, is considered to be carbohydrate. Yet there are some drawbacks with this approach, in that the by difference figure includes a number of non-carbohydrate components such as lignin, organic acids, tannins, waxes and some Maillard products. In addition to this error, it includes cumulative analytical errors from the other analyses. As stated by FAO/WHO (1998), a single figure of total carbohydrate in food is uninformative because it does not reflect many types of carbohydrates in a food that have different potential physiological properties.

Dietary carbohydrate can be divided into two categories which are unavailable and available carbohydrate (FAO/WHO, 1998). A long time ago, in an attempt to prepare food tables or diabetic diets researchers realized that not all carbohydrates could be "utilized and metabolized", i.e. provide the body with "carbohydrates for metabolism". Available carbohydrate refers to that fraction of carbohydrate that can be digested by human enzymes, is absorbed and enters into intermediary metabolism (FAO, 2003). Dietary fiber which can be a source of energy only after fermentation is not included as available carbohydrate.

Available carbohydrate can be obtained by two different ways; firstly, it can be estimated by difference or secondly, by direct analysis. To calculate available carbohydrate by difference, the amount of dietary fiber is analysed and subtracted from total carbohydrate (FAO/WHO, 1998). This yields the estimated weight of available carbohydrate. Yet, the composition of the various saccharides comprising available carbohydrate is not indicated from the calculation. On the other hand, available carbohydrate can be acquired by adding up the analysed weights of individual available carbohydrates.

An optimum diet has at least 55% of total energy from carbohydrate which is provided in various food sources (FAO/WHO, 1998). Globally, more than 70% of the caloric value of human diet comes from carbohydrates (BeMiller, 2003). Carbohydrate-containing foods provide easily available energy for oxidative metabolism as well as vehicles for important micronutrients and phytochemicals. Another role of dietary carbohydrate is to maintain glycemic homeostasis and gastrointestinal integrity and function. Carbohydrates are almost exclusively found in plant, with one major exception which is in milk lactose.

2.6.6 Dietary fiber

Starch polysaccharides like amylose and amylopectin found in cooked starch are digestible, whereas all other non-starch polysaccharides which are components of dietary fiber are indigestible. Dietary fiber is the polysaccharides of plant cell wall such as cellulose, hemicellulose, pectins and hydrocolloids (FAO/WHO, 1998). According to Webb *et al.* (2008), non-starch polysaccharides can be further subdivided into the two general groups of soluble and insoluble based on chemical, physical and functional properties. Lattimer and Haub (2010) described that soluble fiber dissolves in water forming viscous gels that bypass the digestion of the small intestine and are easily fermented by the microflora of the large intestine. They consist of pectins, gums, inulin-type fructans and some hemicelluloses. Foods rich in soluble fiber include fruits, oats, barley and beans (IFST, 2007). Additionally, in the human GI tract, insoluble fibers are not water soluble which do not form gels due to their water insolubility and fermentation is limited. Examples of insoluble fiber are lignin, cellulose and some hemicelluloses. Most foods that contains fiber have about one-third soluble and two-third insoluble fiber (Wong and Jenkins, 2007).

Two basic approaches can be followed to estimate dietary fiber, namely gravimetric and chemical. In the gravimetric approach, by using chemicals or enzymes, digestible carbohydrates, lipids and proteins are selectively solubilized or removed by hydrolysis. Then, materials that are not solubilized or digested are collected by filtration. The fiber residue can be determined gravimetrically. Meanwhile, in the chemical approach, digestible carbohydrates are removed by enzymatic digestion and fiber components are hydrolysed by acid. The value for fiber is the sum of monosaccharide in the acid hydrolysate (BeMiller, 2003).