EFFECTS OF YOUNG CORN EAR ADDITION ON NUTRITIONAL COMPOSITION AND ACCEPTABILITY OF SOME SELECTED TRADITIONAL WHEAT-BASED LOCAL *KUIH*

by

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KESAN PENAMBAHAN JAGUNG MUDA TERHADAP KOMPOSISI PEMAKANAN DAN PENERIMAAN BEBERAPA KUIH TRADISIONAL TEMPATAN BERASASKAN GANDUM YANG TERPILIH

Abstrak

Tepung Jagung Muda (TJM) telah ditambahkan ke dalam tiga kuih tradisional tempatan berasaskan gandum yang terpilih iaitu Kuih Apam, Baulu Cermai dan kek pada tahap 5%, 10% dan 15%. Kuih yang mengandungi 100% tepung gandum dan 0% TJM digunakan sebagai kawalan dalam kajian ini. Objektif kajian ini adalah untuk mengkaji kesan TJM terhadap komposisi pemakanan, ciri-ciri tesktur dan ciri-ciri sensori. Kajian ini menunjukkan bahawa semua komposisi pemakanan Kuih Apam bertambah seiringan dengan tahap TJM yang mana 15% TJM dalam Kuih Apam telah meningkatkan kandungan abu dan protein berbanding dengan sampel kawalan (0%). Kajian ini juga mendedahkan bahawa penambahan TJM sebanyak 15% dalam Baulu Cermai meningkatkan kandungan kelembapan, abu dan lemak berbanding dengan sampel kawalan (0%). Namun begitu, analisis proksimat kek tidak menunjukkan sebarang corak tetapi penambahan TJM sebanyak 15% telah meningkatkan kandungan kelembapan, abu dan protein berbanding dengan sampel kawalan (0%). Selain itu, keputusan kajian ini juga menunjukkan bahawa kandungan serat dalam Baulu Cermai dan kek meningkat seiringan dengan penambahan tahap TJM dalam kedua-dua kuih tersebut. Penambahan sebanyak 10% dan 15% TJM dalam Kuih Apam telah meningkatkan kandungan serat berbanding dengan sampel

yang tidak mengandungi TJM (0%). Di samping itu, keputusan analisi tesktur mendedahkan bahawa penambahan TJM sebanyak 15% meningkatkan kekerasan, kesepaduan, kelentingan, kelikatan dan kekenyalan Kuih Apam tetapi mengurangkan kekenyalan Baulu Cermai berbanding dengan sampel kawalan (0%). Namun begitu, TJM yang ditambahkan ke dalam kek tidak mempengaruhi sebarang ciri tekstur kek. Dari segi penerimaan pengguna, keputusan penilaian sensori mendapati penambahan TJM sebanyak 15% ke dalam Kuih Apam telah mengurangkan skor dalam kesemua atribut sensori. Selain itu, skor yang tertinggi dari segi rasa dan penerimaan keseluruhan telah direkodkan dalam Baulu Cermai yang mengandungi TJM sebanyak 10%. Kek yang diformulasikan dengan TJM sebanyak 10% merupakan sampel yang paling disukai oleh para panel dengan skor yang tertinggi bagi sifat kekenyalan, kelembutan dan rasa. Kesimpulannya, penambahan TJM sebanyak 5% dalam Kuih Apam dan 10% dalam Baulu Cermai serta kek adalah disarankan untuk digunakan dalam penyediaan kuih tradisional tempatan berasaskan gandum yang terpilih demi menambahkan kandungan komposisi pemakanan dan serat tanpa mempengaruhi tekstur dan penerimaan para pengguna.

EFFECTS OF YOUNG CORN EAR ADDITION ON NUTRITIONAL COMPOSITION AND ACCEPTABILITY OF SOME SELECTED TRADITIONAL WHEAT-BASED LOCAL *KUIH*

Abstract

Young corn ear powder (YCP) was added into three selected traditional wheat-based local *kuih* namely *Kuih Apam, Baulu Cermai* and plain cake at the formulations of 5%, 10% and 15%. *Kuih* with 100% wheat flour and 0% of YCP were the control in this study. The aim of the study was to evaluate the effects of YCP on the nutritional composition, textural properties and sensory attributes of these selected *kuih*. The present study showed that all the proximate composition of *Kuih Apam* increased in line with the percentages of YCP. The addition of 15% YCP increased the ash and protein significantly compared to the control (0%). Furthermore, there was a significant increase in the moisture, ash and fat in *Baulu Cermai* added with 15% of YCP compared to the control (0%). On the other hand, the addition of YCP into plain cake did not show any predictable trend in the proximate composition. However, addition of 15% YCP had increased the moisture, ash and protein compared to the control (0%). Apart from that, the results indicated that the total dietary fibre content of *Baulu Cermai* and plain cake increased proportionally with the escalating levels of YCP added. Meanwhile, 10% and 15% of YCP addition in *Kuih Apam* significantly increased the total dietary fibre content compared to the control (0%). Furthermore, texture profile analysis results showed

that the addition of 15% YCP in *Kuih Apam* increased the firmness, cohesiveness, springiness, gumminess and chewiness attributes significantly but 15% of YCP addition in *Baulu Cermai* produced a significantly less chewy sample compared to the control (0%). Meanwhile, the addition of YCP did not affect any of the textural properties significantly. Apart from that, results of sensory evaluation indicated that addition of 15% of YCP in *Kuih Apam* decreased all the sensory attributes scores significantly. On the other hand, the highest score in flavour and overall acceptance for 10% YCP added *Baulu Cermai* was observed. The results also showed that 10% of YCP addition in plain cake was the highest percentage preferred by the panellists with the highest scores in chewiness, tenderness and flavour attributes. In a nutshell, 5% of YCP addition in *Kuih Apam* and 10% of YCP addition in both *Baulu Cermai* and plain cake can be recommended as a maximum level to enhance the proximate composition and total dietary fibre content of the selected traditional wheat-based local *kuih* without jeopardizing the textural properties and the consumers' acceptability of these *kuih*.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

AACC	American Association of Cereal Chemists
AOAC	Association of Official Analytical Chemists Methodology
ANOVA	Analysis of Varians
CCNFSDU	Codex Committee on Nutrition and Foods for Special Dietary Uses
CHD	Coronary Heart Disease
DRI	Dietary Reference Intake
GI	Glycemic Index
HCl	Hydrochloric Acid
NaOH	Sodium Hydroxide
NCCFNM	National Coordinating Committee on Food and Nutrition Malaysia
NCD	Non-communicable Disease
NHMS	Third National Health and Morbidity Survey
RNI	Recommended Nutrient Intakes
RTP	Room Temperature
SRB	Stabilized Rice Bran
TDF	Total Dietary Fibre
TJM	*Tepung Jagung Muda*
TWG	Technical Working Group
TPA	Texture Profile Analysis
USDA	United States Department of Agriculture

WF	Wheat Flour
WHO	World Health Organization
YCP	Young Corn Ear Powder

CHAPTER 1

INTRODUCTION

1.1 Background

Since a couple of decades ago, non-communicable diseases (NCDs) have become an alarming problem in the arena of health. According to Global Status Report (GSR) of World Health Organization (WHO) (2010), NCDs are the main cause of death worldwide. In 1997, the NCDs caused at least 40% and 75% of total deaths in the developing countries and industrialized countries respectively (WHO, 1997). Meanwhile, in 2008, 63% of 57 millions deaths were due to NCDs. Among these deaths, there were more than 9 millions which happened before 60 years old age and 90% of these premature deaths occurred in low-and middle-income countries (WHO, 2010).

Parallel with the increasing occurrence of these diseases, health consciousness is increasing among the world population. Furthermore, people are conscious of the fact that diet is capable of modifying human health. As a consequence, this leads to mushrooming production of functional foods that promote health benefits (Hasler, 1998). There are some bioactive substances found in the food such as antioxidants, plant sterols, prebiotics, probiotics and vitamins. Among all these, dietary fibre plays an important role (Rodríguez et al., 2006) in human health.

Dietary fibre is defined as the storage and structural polysaccharides and lignin found in plants which are not digested in both the human stomach and small intestine (Marlett et al., 2002). Dietary fibre can be divided into water-soluble and water-insoluble components (Gorinstein et al., 2001). Soluble fibres can be found mostly in oats products, dried beans, certain fruits and vegetables. Meanwhile, most plants are good sources of insoluble fibre and the wheat bran is the concentrated form of insoluble fibre (Anderson et al., 1994).

Dietary fibre, being a bioactive substance, has shown some beneficial effects on human. According to Anderson et al. (2009), high consumption of dietary fibre protects the body from diseases as well as enhances the recovery from diseases. People with a higher amount of fibre intake are at lower risk of developing a variety of diseases and health problems (Whelton et al., 2005; Liu et al., 1999; Steffen et al., 2003; Montonen et al., 2003; Lairon et al., 2005; Petruzziello et al., 2006) compared to those who consumed less dietary fibre (Anderson et al., 2009). Furthermore, dietary fibre is also able to increase the stool mass, shorten the passage time, bind the bile acid and lower the blood glucose level as well as cholesterol level (Górecka et al., 2002; Kahlon & Woodruff, 2003).

There are a variety of edible fibres from plants which have been exploited for their palatial usages and other therapeutic applications since long ago. However, many of those products including the dietary fibre in some of the natural products are

insufficiently investigated and their prominent bioactive principles have not been well studied (Wan Rosli & Che Anis, 2012). One of those plants is the young corn or *Zea mays* ear which is commonly consumed as vegetable. It is rich in dietary fibre in which the dried young corn contains 30.4% of total dietary fibre (Wan Rosli & Che Anis, 2012).

Other than that, there are many plants including pulses (Tosh & Yada, 2010), orange peel and pulp (Nassar et al., 2008), mango peel and *bambangan* fruit (M. pajang Kort.) peel (Hassan et al., 2011), passion fruits seed (Chau & Huang, 2004) and lemon albedo (Fernandez-Gines et al., 2004) which are rich in dietary fibre too. Other good sources of dietary fibre which are used to enhance the dietary fibre content in food products are cereals such oats, corn and wheat (McKee & Latner, 2000).

Wheat is an important cereal plant which is globally and frequently used as the main ingredient in food products such as bread, cookies, pastas, flour and other foods (Landillon et al., 2008; Norhaizan & Nor Faizadatul, 2009). In Malaysia, wheat and wheat products are important staple foods which are commonly consumed (Norhaizanand & Nor Faizadatul, 2009). Among all cereal products, wheat flour is the only flour product which can form gluten upon hydration (L'etang et al., 1999; Landillon et al., 2008). The gluten contributes to the formation of the cohesive dough network of the final product. However, the production of the wheat flour will lead to

diminishing of the nutrients especially the dietary fibre in the wheat.

In Malaysia, traditional local *kuih* is one of the various kinds of wheat flour products. The local *kuih* is among the top ten foods which are consumed daily (Norimah et al., 2008). According to the Nutrient Composition of Malaysian Foods, traditional local *kuih* can be categorized into wheat based *kuih*, rice based *kuih* and the miscellaneous (Tee et al., 1997).

In the present study, wheat flour, which is one of the key ingredients in the preparation of some selected traditional local *kuih* will be partially replaced with different levels of young corn ear powder in order to increase the dietary fibre content of the *kuih*. It is hoped that, at the end of this study, I will be successful in developing a few of new healthy local *kuih* which are high in dietary fibre and other essential nutrients.

1.2 Justification of Study

According to Malaysian Technical Working Group (TWG) on Nutritional Guidelines, the Recommended Nutrient Intakes (RNI) for dietary fibre is 20-30g/day for everyone (NCCFNM, 2005). Despite of the adopted recommendation, the dietary fibre daily intakes of Malaysians are still inadequate in which more than half of Malaysian adults consumed less than 20g dietary fibre per day (Ng et al., 2010).

Since the traditional local *kuih* are one of the top ten foods consumed daily in Malaysia (Norimah et al., 2008), hence three traditional wheat-based local *kuih* which were *Kuih Apam, Baulu Cermai* and plain cake were selected from Nutrient Composition of Malaysian Foods (Tee et al., 1997). According to Nutrient Composition of Malaysian Foods 1997, the dietary fibre content was 0.0g per piece of these selected *kuih* (Tee et al., 1997).

Therefore, this study was conducted in an attempt to investigate the ability of young corn powder in increasing the dietary fibre content of the traditional wheat-based local *kuih* as well as increasing the dietary fibre consumption of Malaysian populace.

1.3 Research Hypotheses

Null Hypothesis (H_0)

There are no significant changes on the nutritional composition and acceptability of some selected traditional wheat-based local *kuih* incorporated with young corn ears.

Alternative Hypothesis (H_A)

There are significant changes on the nutritional composition and acceptability of some selected traditional wheat-based local *kuih* incorporated with young corn ears.

1.4 Research Objectives

1.4.1 General Objective

To investigate the effects of young corn ears addition on the nutritional composition and the acceptability of some selected traditional wheat-based local *kuih*.

1.4.2 Specific Objectives

1. To determine the nutritional composition of some selected traditional wheat-based local *kuih* incorporated with young corn ears.
2. To investigate the textural profiles of some selected traditional wheat-based local *kuih* incorporated with young corn ears.
3. To examine the organoleptic quality (sensory) of some selected traditional wheat-based local *kuih* incorporated with young corn ears.

CHAPTER 2

LITERATURE REVIEW

2.1 Non-communicable Diseases (NCDs)

Non-communicable diseases (NCDs) are global crisis which draw the attention of the world population (Beaglehole et al., 2011). NCDs primarily refer to heart disease, stroke, diabetes, chronic respiratory ailments and cancers. The preponderance of the global burden of diseases is the NCDs (Ebrahim & Smeeth, 2005). Between the year of 2010 and 2020, non-communicable death is projected to be increased by 15% (44 million deaths) while South East Asia would be one of the regions in which the increase will exceed 20% (Habib & Saha, 2011).

In South East Asia, Malaysia is one of the countries which have the greatest proportion of chronic mortality rate among those who aged 15 years old and above. Recently in Malaysia, approximately 60 to 70% of total health clinic visits are due to NCDs. In the past five years of time, NCDs was the top five common factor of death in Ministry of Health hospitals (Health Informatics Centre, 2004).

According to the Third National Health and Morbidity Survey NHMS III (2006), the prevalence of NCDs risk factors in Malaysia were physically inactive (43.7%), overweight (29.1%), smoking (21.5%), hypercholesterolemia (20.6%) and obesity

(14.0%). Meanwhile, the prevalence of hypertension and diabetes are 42.6% and 14.9% respectively.

However, there are a large number of these NCDs which can be prevented by reducing the four main behavioral risk factors, namely the use of tobacco and alcohol, lack of exercises, and inadequate consumption of fruits and vegetables (Ebrahim & Smeeth, 2005; Habib & Saha, 2011). The unhealthy diet can be modified to contain less saturated fat, trans fat and more dietary fibre.

2.2 Dietary Fibre

According to American Association of Cereal Chemists (AACC) (2001), dietary fibre is referred to as the edible parts of plants or analogous carbohydrates that are indigestible in human small intestine and will be completely or partially fermented in the large intestine. The examples of dietary fibre are polysaccharides, oligosaccharides, lignin, and associated plant substances (American Dietetic Association, 2002).

On the other hand, Codex Commission on Nutrition and Foods for Special Dietary Uses (CCNFSDU) categorized the dietary fibre into three distinct groups, which are the edible carbohydrate in food; carbohydrate polymers extracted from raw material in food via physical, enzymatic or chemical process and also have

physiological benefits to human health; and synthetic carbohydrate polymers which are physiologically benefit to human health (Cummings et al., 2009). Meanwhile, Dietary Reference Intake (DRI) defined dietary fibre by grouping it into dietary fibre, functional fibre such as resistant starches and total fibre which is also known as the sum of dietary and functional fibre (Trumbo et al., 2002).

In terms of the solubility, dietary fibre is divided into two groups, namely the soluble fibre and insoluble fibre (Tungland & Meyer, 2002) and each of these has different physiology functions on human health. Some of the examples of soluble fibres are inulin-type fructans, oligosaccharides, some hemicellulose, pectins, beta-glucans, and galactomannan gums. Meanwhile, the examples of insoluble fibres included cellulose, hemicellulose and lignin (Tosh & Yada, 2010).

The soluble fibres are capable of lowering the blood cholesterol and regulating the blood glucose levels (Tosh & Yada, 2010). Furthermore, the soluble fibres are able to form gel and bypass the material of digestion in small intestine as well (Lattimer & Mark, 2010). On the other hand, the insoluble fibres will enhance the movement of food materials via the digestive system and hence improve laxation (Tosh & Yada, 2010).

Apart from that, dietary fibre is mainly found in a variety of legumes, vegetables, fruits and grains. Food sources like figs, prunes, beans and whole meal

bread are containing a particularly high amount of total dietary fibres. According to USDA Nutrient Database, half a cup of cooked peas and one cup of raisin bran contain 8.1g and 7.5g of total dietary fibre respectively (American Dietetic Association, 2002).

2.3 Dietary Fibre and Human Health

Since a couple of decades ago, dietary fibre has become the element in foods that are studied for their beneficial roles on human health. These researches including the epidemiological and clinical studies have received considerable attention. There are more than a dozen of existing studies that indicated the positive effects of dietary fibre on human health especially in disease prevention and disease management.

Generally, high consumption of dietary fibre reduces the risk of developing diseases such as coronary heart disease (Liu et al., 1999), stroke (Steffen et al., 2003), hypertension (Whelton et al., 2005), diabetes (Montonen et al., 2003), obesity (Lairon et al., 2005), and certain gastrointestinal disorders (Petruzziello et al., 2006). Moreover, increased consumption of dietary fibre improves serum lipid concentrations (Brown et al., 1999), lowers blood pressure (Keenan et al., 2002), improves blood glucose control in diabetes (Anderson et al., 2004), improves immune function (Watzl et al., 2005) and promotes regularity (Cummings, 2001) which helps in weight loss (Birketvedt et al., 2005).

Furthermore, the roles of dietary fibre in weight management and weight losing have also been established. Weight management is very crucial as obesity is the risk factor for coronary heart disease (CHD) and type 2 diabetes (Kendall et al., 2010). Majority of the high fibre foods are usually high in volume but low in energy density. These foods will promote satiety, decrease hunger and thus control the energy balance (Lunn & Buttriss, 2007; Slavin & Green, 2007). For example, after an increased consumption of cereals, fruits and vegetables, there will be a reduction in the intake of high energy density food, especially the high fat foods owing to the bulky nature of the dietary fibre containing foods.

However, the results varied depending on the nature of the fibre and whether it is naturally available or being added in food (Slavin & Green, 2007). The viscous fibres such as legumes, pectin, guar gum, psyllium and beta-glucan from oats and barley are able to form a viscous gel with water and these are the most effective ones in decreasing the consequential energy intake. On the other hand, some non-viscous fibres like inulin and resistant starch have limited effects despite large consumption of dietary fibre (Slavin & Green, 2007).

Apart from that, most of the diabetes and nutritional associations across the globe recommended a high dietary fibre intake (Weickert & Pfeiffer, 2008). In addition, there are numerous studies which support that consumption of low Glycemic Index (GI) and high dietary fibre diet are effective in managing weight.

Indirectly this will lower the risk of developing coronary heart disease (CHD) and type 2 diabetes (Kendall et al., 2010).

According to Schulze et al. (2004), individuals who consume a combination diet consists of high GI and low cereal fibre will have a 75% greater risk of developing type 2 diabetes than those consuming a combination diet of high-cereal fibre and low GI. Evidence from some intervention studies done on subjects with type 2 diabetes also support the beneficial role of dietary fibre in improving glycemic control and this was assured by a meta-analysis (Anderson et al., 2004).

Apart from that, with the viscosity of the viscous fibres, the process of nutrients digestion will be decelerated by hindering bulk diffusion of the foods across the intestinal lumen and thereby lessen the nutrients absorption (Kendall et al., 2010). Following this, the postprandial glucose (Weickert & Pfeiffer, 2008) and the insulin response will aid in preventing and managing the problems of insulin resistance and type 2 diabetes (Kendall et al., 2010).

As it was mentioned earlier that obesity is one of the risk factors for some NCDs such as heart disease (Lopez et al., 2006), hence the decrease in the rates of obesity and the risk of developing type 2 diabetes can be indirectly linked to a decreased rate of coronary heart disease occurrence (Kendall et al., 2010). Besides, one of the proposed mechanisms of hypocholesterolemic effect of soluble dietary fibre is by

acting on the serum cholesterol and low density lipoprotein cholesterol in which they will bind to the bile acids and increases the excretion (Kirby et al., 1981). Furthermore, fermentation of dietary fibres will lead to production of short-chain fatty acid proprionate and reduction in cholesterol synthesis (Wright et al., 1990).

A high dietary fibre intake is associated with significantly lower prevalence for coronary heart disease, stroke, and peripheral vascular disease (Liu et al., 1999; Merchant et al., 2003; Liu et al., 2000). Moreover, in seven cohort studies, it was shown that coronary heart disease prevalence was 29% lower in those whose dietary fibre consumption was the highest compared to those with the lowest dietary fibre consumption (Anderson et al., 2009).

There are studies which indicated that for every 10g of extra fibre in a diet there would be a 17-35% reduction in the mortality risk of coronary heart disease (Pereira et al., 2004; Streppel et al., 2008). Besides, higher consumption of whole grains were associated with 26% reduction in prevalence of ischemic stroke (Anderson et al., 2009). Meanwhile, the consumption of vegetables and fruits was associated with a lower risk for ischemic stroke (Johnsen et al., 2003) and it had favorable effects on the carotid artery atherosclerosis development (Wu et al., 2003). Therefore, based on the mounting consistent scientific evidences, it is recommended to consume a generous amount of high fibre foods in the prevention of coronary heart disease (Pereira et al., 2004).

Apart from the NCDs discussed earlier, dietary fibre also plays an important role in certain cancers. It is regarded as an important risk factor for cancer (Suzana et al., 2004). According to Kendall et al. (2010), there were several international population and migrants studies which successfully showed that the high fibre diets are related with the reduced prevalence of cancer, especially the breast and colon cancers. Besides, European Prospective Investigation on Cancer study showed that there was a 40% decrease in colorectal cancer risk between the lowest (15g/ day) and the highest (35g/ day) quintiles of dietary fibre consumption (Bingham et al., 2003). Furthermore, a pooled analysis of 13 prospective cohort studies done with 6 to 20 years of follow-up summed up that the dietary fibre was inversely related with the colorectal cancer risk (Park et al., 2005).

Moreover, the relationships between cancer and diet, physical activity as well as weight were published by World Cancer Research Fund and it does support the relationship between dietary fibre and colorectal cancer (WCRF/AICR, 2007). There is another fascinating results in which the respondents of a case-control study with the highest quintile of fibre consumption indicated a reduction of 27% in the risk of developing colorectal adenoma (Peters et al., 2003). Other dietary factors such as energy and fat intake are also related to cancer among Malaysians. It is, therefore, important for Malaysians to consume a high fibre low fat diet and many fruits as well as vegetables in order to prevent cancers (Suzana et al., 2004) as fibre obtained from grains, fruits and cereal was related with the largest reductions in the risk of

colorectal cancer (Kendall et al., 2010).

Dietary fibre is also important in gastrointestinal tract health. Dietary fibre consumption reduced the prevalence of hiatal hernias and gastroesophageal reflux disease (GERD), peptic ulcer disease, gallbladder disease, appendicitis, hemorrhoids, colorectal cancer and diverticular disease (Burkitt & Trowell, 1975). Diverticular disease is one of the classical fibre-deficiency diseases and a high consumption of dietary fibre is important in protection, amelioration, and prevention of recurrences (Frieri et al., 2006).

2.4 Dietary Fibre Intake

The recommendation for dietary fibre intake ranges from 25g to 38g dietary fibre per day or 14g dietary fibre/1,000kcal (American Dietetic Association, 2008; WHO, 2003). Based on the minimum amount of fibre needed to produce a positive effect on health and disease, it is set that the adequate intake of dietary fibre was 38g and 25g per day for men and women respectively (Rose et al., 2007). Meanwhile, the recommendation of dietary fibre intake for children whose ages are more than 2 years old is equal to or more than their age plus 5g per day. As for those who aged 20 years old and above, it is recommended to consume 25g to 35g dietary fibre per day (Williams et al., 1995).

In Malaysia, after taking into consideration the practical implications and the current estimated fibre intake of Malaysians, it was recommended to consume 20g to 30g of dietary fibre per day and this recommendation was consistent with WHO recommendation in 1990 (Malaysian Dietary Guidelines, 1998; NCCFNM, 2005).

Despite of so many existing recommendations on dietary fibre intake, the dietary fibre intakes of Malaysians are still not meeting the recommendations. For an instance, the average Malaysians living in city areas consumed only approximately 180g of vegetables and fruits and 13-16g of total dietary fibre (Ng, 1995). This amount is still very low compared to 27-40g recommended by WHO (1990), partially due to the fact that Malaysian adults seldom consume the breakfast cereals (Ng, 1997). Besides, another evidence from Malaysian Adult Nutrition Survey (MANS) via 24-hour dietary recall indicated that the consumption of dietary fibre of more than half of Malaysian adults populations were less than 20g/day (Ng et al., 2010).

Since many years ago, the fact that there is inadequate dietary fibre intake has emerged. The scenario of lack of dietary fibre intake as we can see in Malaysia happens in other parts of the world as well. For example, in Australia, the dietary fibre consumption was about 25g/head/day (Topping, 1993) while the consumption of non-starch polysaccharides in the United Kingdom was approximately 12.5g/day (Cummings & Bingham, 1992).

Apart from that, according to the Malaysian Adult Nutrition Survey (MANS) 2003, the average Malaysian adults consumed approximately 290g of fruits and 134g of vegetables a day, which indicated that the recommendation of 400g of vegetables and fruits a day suggested by WHO (1990) is quite practicable (Ng et al., 2010). Hence, the dietary fibre intake should be increased in order to achieve the recommendations. In conjunction with that, WHO had recommended that a whole grains rich diet and at least 400g/day of vegetables and fruits, out of which 30g should consists of pulses, nuts, and seeds should enable one to achieve a dietary fibre intake of more than 25g/day (WHO, 1990; WHO, 2003).

2.5 Functional Food

All foods are functional to some extent as they possess flavour, aroma and nutritive value. But many foods from animals and plants sources which contained physiological active components including the phytochemicals or zoochemicals are being studied for their additional physiological advantages such as reducing the risk of diseases or enhancing health (Hasler, 2002). These researches led to the global attention on the growing of the foods which are known as the functional foods (Hasler, 2002).

Functional foods are the whole foods which are fortified, enriched, or enhanced, which have a potentially beneficial impact on health when these foods are consumed

regularly and at effective levels with a variety of diets (American Dietetic Association, 2004). On the other hand, The Institute of Medicine of the National Academy of Sciences defined the functional foods as the concentrates of one or more ingredients or food components that are modified to increase their contributive roles in the healthful diets (Committee on Opportunities in the Nutrition and Food Sciences, 1994).

Despite of the fact that many foods are being investigated intensively for their potential benefits on human health, there are only a small quantity of them are successfully being approved by Food and Drug Administration (FDA) for bearing a health claim (Hasler, 2002). These including oat soluble (ß-glucan) fibre (Department of Health and Human Services, 1997), soluble fibre from psyllium seed husk (Department of Health and Human Services, 1998), soy protein (Department of Health and Human Services, 1999) and sterol-and stanol-ester-fortified margarine (Department of Health and Human Services, 2000).

Due to the increasing demand, there are many studies done on foods nowdays. For example, the incorporation of rice bran in *Kuih Baulu* (Rosniyana et al, 2011) and in *Dodol* (Rosniyana et al., 2010), pearl millet flour in substitution of refined wheat flour in preparation of banana cake (Anu et al., 2008) and substitution of wheat flour with rice flour and rice bran flour in bake products (Pitchaporn et al., 2009).

In a previous study in which the rice bran was used in *Kuih Baulu* to produce a functional food, the rice bran flour, a mixture of stabilized rice bran (SRB) and rice flour, were prepared in several ratios, namely, 0:100, 10:90, 20:80, 30:70 and 40:60 (Rosniyana et al., 2011). The result showing the higher fibre content in *Kuih Baulu* incorporated with stabilized rice bran was similar with the result of a study done on *Dodol* (Rosniyana et al., 2010) in which it was observed that the dietary fibre was more than 6g/100g in the *Dodol* produced with addition of 40% and 50% levels of SRB and these *Dodol* can be categorized as high fibre products.

Meanwhile, the study by Anu et al. (2008) also showed supportive results in which the banana cake incorporated with pearl millet flour has higher protein, fat, ash and crude fibre content compared to that without pearl millet flour while the results of the study by Pitchaporn et al. (2009) showed that protein, fat, ash and fibre of the flakes were increased with increasing proportion of rice bran powder.

Apart from that, incorporation of young corn (Zea Mays) ears powder into cookies as well as bread had shown that the protein and total dietary fibre content of both of the food products increased in line with the increasing level of young corn ears powder added (Wan Rosli & Che Anis, 2012; Lim & Wan Rosli, 2012). The former study results concluded that young corn ears aqueous extract residues contain dietary fibre compounds and it can be potentially used as alternative fibre source in processed food products (Wan Rosli & Che Anis, 2012).

Nonetheless, despite that there are many researches conducted to produce more functional foods, the consumers' acceptance play an important role in the market availability of those functional foods.

2.6 Consumers' Acceptability

According to International Food Information Council March (2002) survey, there were 94% of consumers agreed that some of the foods have additional health benefits that exceed the basic nutrition while 85% of them were interested to learn more about the functional foods. Meanwhile, there were approximately 53% of consumers who related the foods such as fish oil or fish, garlic and fibre with heart health (International Food Information Council, 2002).

Since there was an increase in the consumers demand for a healthier food supply, a wide variety of functional foods have evolved massively and more importantly, the functional foods are on an increasing percentage of all new food products (American Dietetic Association, 2004). However, the consumers' acceptance regarding the functional foods is not always unlimited, in which one of the major determinants was the taste besides the trustworthiness of the health claims (Verbeke, 2006). This can be further confirmed in a study conducted by Ares et al. (2009) which reported that the consumers rated the puddings enriched with high percentage of high-amylose maize starch (HAMS) with a lower acceptability in spite of knowing it might leave a

beneficial health impact.

Meanwhile, there were a few studies done on the consumers' acceptability on functional foods, for example, Mialon et al. (2002) studied the effect of information about the dietary fibre content of bread and English muffins on the consumers, Sosa and Hough (2006) investigated the effect of price and brand on the sensory acceptability of alfajor, Rosniyana et al. (2011) studied about the acceptability of *Kuih Baulu* incorporated with stabilized rice bran and Ares et al. (2009) studied about the new functional fibre in puddings as well as its effects on sensory properties and consumers' acceptability.

Nonetheless, many studies have managed to confirm that taste is the major factor that influences the general food choices of the consumers (Grunert et al., 2000; Richardson et al., 1994; Urala & La¨hteenma¨ki, 2003). Meanwhile, in terms of functional foods, taste expectations and experiences were reported to be two extremely important factors when making food choice decision within this food group (Childs & Poryzees, 1997; Gilbert, 2000; Tuorila & Cardello, 2002).

According to Verbeke et al. (2006), the bitterness, astringent, salty or acrid off-flavours are commonly caused by the enhancement of food functionality with plant-based phytonutrients or bioactive compounds. Thus, it will be hard for the consumers to compromise on the flavour and aroma or the functional foods for their

health benefits (Augustin, 2001; Cox et al., 2004; Gilbert, 2000).

Apart from the taste, the textural properties and the mouth feel of the functional foods are also very important in determining the acceptability of the consumers. According to Yue and Waring (1998), the consumers tend to perceive the fibre as possessing strong flavour, dry mouth feel, coarse in texture as well as unpalatable. Furthermore, the negative characteristics of high fibre baked products are often related with poor sensory properties such as dark colour, masking of all flavours and poor mouth feel (Baixauli et al., 2008). All these unpleasant attributes caused the researchers to conclude that majority of the consumers will not accept the functional foods with the taste poorer than the original foods (Hilliam, 2003; Tuorila & Cardello, 2002; Verbeke, 2006).

In a nutshell, healthy food selections are often in conflict with the pleasurable eating and changes in the dietary habits seemed to be difficult due to the fact that the food selections of the consumers are conquered by the preferences in taste and the texture (Baixauli et al., 2008). Furthermore, there is a necessity for the consumers to have a clear understanding and convincing scientific criteria in documenting the health benefits and claims (International Food Information Council, 2002) so that healthy food selections can be made. Urala and Lahteenmaki (2004) had indicated that the consumers may still willing to compromise with the sensory properties for some functional foods that possess a strong health claim.

Due to the importance of consumers acceptability towards a newly developed functional foods, there comes the role of sensory evaluation in the studies to investigate the consumers' acceptance of those food products studied. For an instance, Lim and Wan Rosli (2012) showed that the highest percentage of young corn ears powder in the bread which was accepted by the panelists was 4%. Further addition of young corn ear powder would lead to a decrease in the preference in terms of the flavour of bread.

2.7 Young Corn Ears

Young corn or baby corn is the ear of the maize plant *(Zea mays* L.). It is harvested when it is young, particularly before or just after the silks grow and there is no fertilization taken place yet, depending on the cultivars. Usually young corn is used as vegetable or being removed because it is still not well known with its nutrient contents and potential functional properties (Wan Rosli & Che Anis, 2012).

Young corn is used primarily in Asian cuisine and the consumption of this product is the highest in Asia (Duncan, 1999). Usually in the market, the young corn ears which are light yellow in colour with regular row arrangement, 10 to 12cm in length and 1.0 to 1.5cm in diameter are preferred (Muthukumar et al., 2005). The dehusked young corn ears can be eaten as a vegetable, salad, pickle, soup and many more (Tiwari et al., 1999).

Young corn has delicate flavour and crispy mouth feel which explain about the high demand in Thailand and overseas countries (UNDP, 2001). It is estimated that Thailand contributed for 80% of the world's trade in baby corn (RAP, 1995). In the year of 2011, Thailand was the country in producing and exporting baby corn while India was shown to have the potential to produce baby corn due to its low production cost (Anonymous, 2011b). Field fresh, a company in India, commanded a 10% supply share for baby corn to the England market and the cost standards were almost same as those in Thailand (Pandey et al., 2010).

Young corn is free from pesticides. The nutrient contents of young corn are comparable to other vegetables such as tomato, cucumber, cauliflower, cabbage and eggplant. The by-products of young corn, for an instance tassel, silk, young husk and the green stalk can be used as cattle feed (UNDP, 2001). Due to the fact that there is a lack of knowledge on its nutritional values and possible functional properties, it is seldom utilized as raw food materials (Wan Rosli & Che Anis, 2012).

About two decades ago, young corn and maize were considered as grain for the poor ones or use as animal feed, rather than a vegetable for human consumption. When the researches and developments on young corn started to take place, the farmers who started to cultivate on this plant are mushrooming. Hence, the domestic markets for young corn in Thailand grow speedily. In short, the cultivation and massive production of young corn in Thailand have benefitted people from all walks