UNIVERSITI MALAYSIA KELANTAN

Physical Properties and Sensory Acceptability of Cracker Made from Pumpkin (*Cucurbita mochata*) Flour During Storage

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F15A0267

A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Product Development Technology) with Honours

Faculty of Agro Based Industry

Universiti Malaysia Kelantan

2019

DECLARATION

I hereby declare that the work embodied in this report is the result of the original research except for the excerpts and summaries which I have just described the source.

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ACKNOWLEDGEMENT

This study partially supported by Faculty of Agro Based Industry. I thank to Dr. Ikarastika Rahayu Binti Abdul Wahab as my final year project coordinator for Product Development Technology course for give the instruction to do the research. Next, I thank to my supervisor Dr. Leony Tham Yew Seng and my co-supervisor Dr. Nurhanan Binti Abdul Rahman who had guided me and gave me some knowledge for this research. Moreover, they had approved and supported me to do this research and ensured this study had been done successfully.

I also would like to thank to my parent because allowed me to do this study and supported me by giving a spirit to finish this study. I also like to show my gratitude to all my friends that helped me to give a moral support and share any information in order to finish this study.

Last but not least, I would like to thanks to all laboratory assistances that always had time and space to guide me during doing this study and using the instruments in the laboratory. Without all of the people, maybe this study cannot be done until now.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOL

Reference No.		Page
Fe	iron	8
Ca	calcium	8
Na	sodium	8
K	potassium	8
Mg	magnesium	8
P	phosphorus	8
NaCl	sodium chloride	15
a_w	water activity	39

LIST OF ABREVIATIONS

Reference No.		Page
FW	fresh weight	8
DF	dietary fibre	11
TDF	total dietary fibre	11

ABSTRACT

Physical Properties and Sensory Acceptability of Cracker Made from Pumpkin (Cucurbita mochata) Flour During Storage

The purpose of this study was to determine the physical properties and sensory acceptability of cracker made from pumpkin (*Cucurbita mochata*) flour. Pumpkin flour at four levels (20%, 30%, 40% and 50%) of flour substitution was formulated. Cracker without pumpkin flour served as control. Colour properties (lightness (*L**), redness (*a**) and yellowness (*b**)) of cracker were determined using chromameter while texture properties (hardness, fracturability and cohesiveness) were conducted using texture analyzer. The results showed that the colour intensities of *L**, *a**, *b** had increased with increased level of pumpkin. In texture analysis of the hardness, fracturability and cohesiveness of cracker with increased level of pumpkin were increased. In sensory evaluation, the results showed that the cracker incorporated with 20% of pumpkin flour had the highest score in colour, aroma, flavour, taste and overall acceptability. In Total Plate Count test for 20% pumpkin flour containing in cracker showed very low numbers of colony (<100 CFU/g).

Keywords: Cracker, Pumpkin, Texture, Colour, Sensory Evaluation

ABSTRAK

Ciri fizikal dan Penerimaan Deria untuk Kraker Diperbuat Daripada Tepung Labu (*Cucurbita mochata*) Semasa Penyimpanan

Tujuan kajian ini adalah untuk menentukan ciri fizikal dan penerimaan deria terhadap kraker yang diperbuat daripada tepung labu (*Cucurbita mochata*). Tepung labu pada empat tahap (20%, 30%, 40% dan 50%) penggantian tepung telah dirumuskan. Kraker tanpa tepung labu dijadikan sebagai kawalan. Ciri warna (keterangan (*L**), kemerahan (*a**) dan kekuningan (*b**)) kraker telah ditentukan menggunakan chromameter manakal ciri tekstur (kekerasan, kerapuhan dan kohesif) telah dijalankan menggunakan penganalisis tekstur. Keputusan menunjukkan keamatan bagi *L*, a*, b** telah bertambah dengan bertambahnya tahap labu. Dalam analisis tekstur bagi kekerasan, kerapuhan dan kohesif bagi kraker dengan penambahan tahap labu adalah bertambah. Dalam penilaian deria, keputusan menunjukkan kraker diperbuat dengan 20% tepung labu memberikan nilai tertinggi dalam warna, aroma, perisa, rasa dan penerimaan keseluruhan. Dalam ujian jumlah pengiraan plat untuk 20% tepung labu dalam kraker menunjukkan jumlah koloni yang sangat rendah (<100 CFU/g).

Kata kunci: Kraker, Labu, Tekstur, Warna, Penilaian deria

CHAPTER 1

INTRODUCTION

1.1 Research Background

Foods that are consumed by the consumers need to be a healthier product rather than is cheap, delicious and can satisfy their hunger. The product that is healthier is a product that contains or provides necessary nutrients for humans. However, the food product that being claimed as rich in nutritional value or natural nowadays might had a chemical add on as their ingredients as their preservatives or flavour enhancer (World Health Organization, 2009). The less number of consumption of vegetables and fruit with unhealthy eating lifestyle in some people can make them had a highly risk in getting various type of diseases. Thus, the food product development is important in improving the food which contain higher in nutritional value and natural ingredients that can give a better health for human (Hasler-lewis, n.d).

In Malaysia, the bakery industry has grown tremendously over the recent years. The bakery products are variety due to its addition of value added ingredients according to Sudha *et al.,* (2007). Among all of the added ingredients in the bakery products, dietary fibre is the common ingredients that gained attention among producer. Important sources that are high in dietary fibre are come from the fruits and vegetables although the contents are not as high as in the cereals. Pumpkin is one of the vegetables that are rich in the dietary fibre content and usually not being consumed as raw or cooked as meal but also processed in various kinds of products especially food products such as chips, juices and puree (Aziah & Komathi, 2009).

The Cucurbiteae family also referred as cucurbits that forms a very large group those approximately about 130 genera and 800 species in the world and can be cultivated easily in warmer place and also can be make a popular food crop plants (Perez Gutlerrez, 2016). The most three common types of pumpkin world-wide with high production namely *Curcurbita pepo, Curcurbita maxima* and *Cucurbita mochata*. The most commonly type of pumpkin that being consumed in Asia and United States region is *Cucurbita moshata* (Lee, Chung & Ezura, 2003). This type of crop plant that is known to have a beta-carotene that is good in antioxidant activities known to give the pumpkin vibrant colour and had received high attention in this recent years from the researcher (Adhau, Salu & Raut, 2015). In some research, the risk in developing certain cancer can be reduce in consuming diet that is rich in beta-carotene and also offers protection against cardiovascular diseases (See, Wan & Noor, 2007). Pumpkin also contain in a good source of vitamins such as B2, C and E, potassium, large quantity of fibre and phenolic compound (Henriques, Guine & Barroca, 2012).

Cookies and crackers are among the most popular foods that are low-moisture that made with wheat flour as the main ingredients. Crackers usually prefer wheat flour that is contain high in gluten protein strength due to gluten development in the dough of the cracker during mixing and sheeting is important factor in maintaining the quality of the finished product. The most important ingredients for the cracker that make it differ from others bakery product such as cookies is the sugar concentration. Cracker usually had a lower concentration in sugar with lower than 30% in a typical cracker formula (Kweon, Slade, Levine & Gannon, 2013). Therefore, the objectives on this research are to determine the physical analyses which are colour and texture for the cracker in different concentration level of pumpkin flour. Besides, maintain the quality of the product by enhancing the product shelf life of the cracker by addition of pumpkin as ingredients. Then, the sensory acceptability among the consumers regarding this new development type of cracker was determined.

1.2 Problem Statement

This project investigations the addition of different percentage of pumpkin Flour in the cracker. There are a lot of researches have proved that the pumpkin can be used in the food product as it contain high level of dietary fiber (Sealeaw & Schleining, n.d). Pumpkin was found abandoned and has limited usage in development of products especially in bakery products and usually pumpkin just being eaten in raw style. There are some people avoid eating the fruit and vegetables in fresh thus this might cause them to have vitamin or mineral deficiency. Then, less amount of nutritious food intake by Malaysian. Most of the products that being market contains in high amount of sugar with additional of chemical preservatives, flavour enhancer and colour that can cause bad effect to consumer especially for those people that already had health problems.

The awareness regarding importance of consuming of nutritious foods especially fruits and vegetables in preventing diseases and improving quality life had been increased by people. The major problem in purchasing fresh fruit and vegetables is their short life cycle. The fresh-cut pumpkin shelf life is very short and tends to deteriorate during storage (Gordana *et al.*, 2016). This shelf life problem not just makes the product can be stored in a short term but it also will effect in economic loss. Hence, the development of fruits and vegetables based products will lower the deterioration of the fresh products and also decreased the commodity being wasted.

1.3 Objectives

1. To determine texture and colour analysis of the cracker in different concentration of pumpkin flour.
2. To determine the sensory evaluation of the cracker in different concentration of pumpkin flour.
3. To determine the microbial growth in the cracker in addition of pumpkin flour using total plate count method.

1.4 Hypothesis

Ho: Incorporation of pumpkin flour in cracker has no effect to the colour, texture and shelf life.

H_1: Incorporation of pumpkin flour in cracker has effects to the colour, texture and shelf life.

Ho: Sensory properties of incorporation of pumpkin flour in cracker received lower acceptability by consumers.

H_1: Sensory properties of incorporation of pumpkin flour in cracker received higher acceptability by consumers.

1.5 Scope of Study

The study will focus on the physical properties, microbial growth and sensory acceptability of the cracker when being added with pumpkin flour and also to develop a food product derived from the pumpkin flesh during storage. Physical analysis of the cracker being added with the pumpkin are determine in this study are the texture and colour. Then, the cracker will be test for total plate count to observe the bacterial growth within four weeks to known the shelf life and quality of the cracker products. A normal sensory evaluation will be carried out to know the acceptability of the consumers towards the cracker. The colour, aroma, flavor, taste and overall acceptability of the cracker will be tested upon random 35 people around Jeli campus.

1.6 Significance of Study

From this research project, the abundant of local plant can be utilized into something that can provide benefits to the future. The usage of this plant in food product especially in bakery can increase the nutritional value, texture and flavour.

CHAPTER 2

LITERATURE REVIEW

2.1 Pumpkin (*Cucurbita sp.*)

Pumpkin belongs to the family *Cucurbitaceae* with the genus *Cucurbita*. This vegetable is comprised of *Cucurbita moschata*, *C. pepo*, *C. maxima*, *C. mixta*, *C. ficifolia* and *Telfairia occidentalis Hook*. Pumpkin which originated from America, also includes squash, cantaloupes, cucumbers, watermelons and gourds. The five major countries in the world that producing pumpkin are China, India, Ukraine, Egypt and United States. The major pumpkin producing in states of Malaysia are Terengganu, Kelantan, Perak and Kedah. The three most common types of pumpkin worldwide with high production line are namely *Curcurbita pepo*, *Curcurbita maxima* and *Curcurbita moschata.* Some type of pumpkin that most commonly eaten in both Asia and United States region is *C. moschata* (Lee *et al.*, 2003).

Pumpkin can be found in various shapes, sizes and colours. The stems are soft, slightly hairy and tendrils are branched. Leaves are dark green and the yellow-orange characteristic colour of pumpkin is due to the presence of carotenoids (See, Wan Nadiah &

Noor Aziah, 2007). The colour of the pumpkin pulp can be from brown, completely white, bright orange to greenish light and can be very sweet, smooth in taste with usually non-fibrous (Jacobo *et al.,* 2011). In addition, the pumpkin shapes can be found in the range from round to oblong among varieties and the size is less than 0.45 kg to more than 4.50 kg for each (Tonny, Noble, Peter, Nicholas & Ratibu, 2015).

Figure 2.1: Picture of pumpkin (*Cucurbita moschata*)

2.2 Nutritional Composition

Pumpkin can provides multiple health benefits, being rich in phenolic compounds, flavonoids, vitamins (A, B1, B2, C and E), minerals (Fe, Ca, Na, K, Mg, and P) and dietary fibre (Adubofuar, Amoah & Agyekum, 2016). Vitamin E that content in the pumpkin pulp is found with the value 1.06 mg/100 g fresh weight (FW) that acting as an 7 antioxidant in the body (Seleim, Hend & Manal 2015). Any activities leading to the launching new attractive product on *Cucurbit sp.* are advisable due to the high antioxidant content that is known in inhibiting cancer and cardiovascular disease (Javaherashti, Mahmood & Habiballah, 2012). However, the major contributory factors in the high nutritional value of pumpkin fruit is carotenoids with (>80%) of β-carotene that is crucial for maintaining eye health (Gordana, Zdunić, Nicrki, Park, Zork & Ruiyi, 2016).

2.3 Pumpkin Flour

Pumpkin flour that prepared by drum drying or hot air drying techniques was reported to be more stable, versatile and can be used throughout the year (Kulkarni & Joshi, 2013). Drying is one of the most widely used primary methods in food preservation that can extend the shelf life (Akpinar & Bicer, 2004). A new range of products and flour can be stabilized is created by drying method by reducing the moisture content or its water activity (Hayta, Alpaslan & Baysar, 2002). Drying the products was reported can longer the shelf life, decreased the space used for storage and reduces the weight during the transportation (Ertekin & Yaldiz, 2004). The processed pumpkin rather than fresh pumpkin will meet the demand for this type of food throughout the year (Doymaz, 2004).

Pumpkin flour produced from the mature pumpkin (*Cucurbita mochata*) that contain 78.77% carbohydrate, 1.34% protein, 1.34% fat, 7.24% ash, 2.9% fibre, and 6.01% moisture. The sample contain 7.29 mg/100 g beta-carotene with the value of the colour analysis of L^* 57.81, a^* 8.31, b^* 34.39 and 0.24 water activity (Pongjanta, Naulbunrang, Kawangdang, Manon, & Thepjaikat, 2006). It also can be used as thickener in soup, gravy, fabricated snacks and as ingredients in bakery products such as cookies, sandwich, cake and instant noodles (Pongjanta *et al.*, 2006). It also been used as natural colourant (yellow colour) with most preferable in the taste, texture, appearance and acceptability when applied as ingredient in the bakery products besides as a source of beta-carotene (Lee *et al.*, 2003).

2.4 Beta Carotene

The main group of colouring substances in nature is the carotenoids. Carotenoids are responsible for most of red, orange and yellow colours of fruits and vegetables (Astorg, 1997). The attractiveness and acceptability of the product is depending on the stability of the carotenoids during the operation and storage of the product. The degradation of the pigment will affect the colour, flavor and nutritive value inside of the vegetable. Isomerization, oxidation and fragmentation of the carotenoids molecules are the common degradation type that promoted by the heat, light and acids (Namitha & Negi, 2010). Beta-carotene is fat-soluble pigments from plant that is good for human nutrition. It is important for human eye light reception due to act as precursor to vitamin A in human body besides act as cancer prevention (Namitha & Negi, 2010).

Pumpkin that is a green-yellow vegetable in beta-carotene has attracted attention as a healthy food. Nineteen carotenoids were detected in the *Cucurbita moshata* variety ‘’Baianinha’’ and the principal carotenoid was the beta-carotene. It had about 74% of an average total carotenoids content of 317.8 micrograms/g. In *Cucurbita maxima* variety of ‘’Jerium Caboclo’’, carotenoid that found were 11 with the beta-carotene and lutein as it major pigment about 27% and 60% respectively. The average total of carotenoids content is 78.4 micrograms/g (Arima & Rodriguez-Amaya, 1990).

2.5 Dietary Fibre

The demand of food that is rich in dietary fibre had increased in the recent decades and lead to the development of many fibre rich products and ingredients (Drzikova *et al.*, 2005). The specific properties of dietary fibre reported play an important role in preventing and treating various gastrointestinal disorders such as constipation, obesity, coronary heart disease, colorectal cancer and diabetes (Bingham, Day, Luben & Ferrari, 2003). The World Health Organization currently recommends consumption of foods that was containing >25 g (30-45 g) of total dietary fibre per day (WHO, 2003). The dietary fibre is composed of total dietary fibre (TDF) that includes both soluble dietary fibre (SDF) and insoluble dietary fibre (IDF). Both kind of dieatary fibre are complement with each other. 70-50% of insoluble dietary fibre and 30-50% of soluble dietary fibre is considered as a balanced proportion (Grigelmo-Miguel *et al.*, 1999).

Soluble fibre can be found in fresh and dried fruit, vegetables, oats, legumes and seeds. Examples of the soluble fibre are pectins, gums, mucillages and some hemicellulose. The viscosity of the intestinal contents can be increased and cholesterol absorption being reduced using some of soluble fibre. Some other soluble fibres were fermented by the bacteria in the large intestine for maintaining the good colon health and increasing in the mineral absorption. Production of short chain fatty acids such as propionate and butyrate was resulted from the fermentation of soluble fibre. The fatty acid named butyrate found acted as a protective agent against experimental tumor genesis of the cells. Propionate could be related to hypocholestrolemic effects (Redondo-Cuenca, Goni & Villanueva-Suarez, 2014).

Insoluble fibre can be found in the plat cell walls of the whole grain bread, whole grain cereals, fruits and vegetables. Examples of the insoluble fibre are cellulose, lignin and hemicellulose. Many of insoluble fibre are not fermentable. The characteristics of insoluble fibre are has a high water holding capacity, increase fecal bulk and reduces the gastro intestinal transit time. This effect may be related to the treatment and prevention of some of the intestinal disorders (Redondo-Cuenca *et al.*, 2014).

2.6 Starch Content

Pumpkin is classified as a fruit vegetable that is consumed by many peoples as staple that provide a substantial amount of calories during consumption. Pumpkin is found to have starch that amount may go up to 60% (Corrigan, Irving & Potter, 2000). Starch is major carbohydrate that exists in the plant storage organs and the most important biopolymers on the planet also with cellulose. It was calculated as calories and represents 80% of the food supply in the world (Guan & Keeling, 1998). Starch also can be used as animal feed and important raw material in industrial such as in bakery industries. Starch is produced as end product of carbon fixation during the photosynthesis and is accumulated in storage organ of the plant. A mixture of essentially linear (amylose) and highly branched (amylopectin) polymers are consisting in most plant starches with ratio of approximately 1: 3 (Guan & Keeling, 1998).

Starches that got from wheat, maize and potato is among the highest used in food and non-food industries yet an alternative starch sources could be explored in order to increase the potential contribution to agricultural development and general economic growth. Starch processing is more profitable when conducted alongside flour processing that employs similar equipment. Waste from the starch processing could be incorporated into the flour since the margin are still small, the sales of waste materials from the starch is important factor in longer term sustainability of the process.

2.7 Cracker

Cracker is one of the bakery industries that get higher demand over the recent years. According to Sudha *et al.,* (2007), bakery products are varied due to it addition ingredient as added value. Among all of the added value ingredients, dietary fibre gained the higher attention. Crackers are a wide range of products that had characteristics of crispy, open texture, less sweet and savoury flavours (Davidson, 2016). In general, crackers usually may have some of the following features that enhance the texture during it baking process which are dough are fermented and leavened with the ingredients such as yeast and sodium bicarbonate. It also had a high water content ranged 15% to 25% in the dough. The sheet of the dough also made up from multiple thin layers. Other than that, some of the cracker processing are cut and baked in strips or complete sheets then, broken into individual pieces after finished baked. The colour contrast is between dark blisters and a pale background colour (Davidson, 2016).

In commercial cracker producing, flour usually used as main ingredient, instead of using the purified starch that extracted from the flour at some expense. However, there are some flour that come from the natural plants can be practically considered as starch without any purification. The starch should only contain only amylose and amylopectin but with some of other component exist is acceptable. Starches that are commonly used for the cracker making in a huge scale are the cassava and sago starch due to give a good expansion of the finished product rather than other starches. Cassava is preferred in Thailand while Sago is more preferred in Malaysia and Indonesia. Properties of those two commonly used starches have been reported by many research groups (Moorthy, 2002, Aryee *et al.*, 2006).

2.7.1 Wheat Flour

Flour is the most important ingredients in cracker because it modulates the specific characteristics of the bakery products itself. Flour usually consists of protein (10-12%), starch (70-75%) and other carbohydrates, ash, non-starch polysaccharides (2-3%), ash, lipids (2%), water (14%), small amounts of minerals, vitamins and enzymes (Geosaert *et al.*, 2005). Wheat flour is the most commonly used type of flour that provides a light palatable, well-risen when processed into fermented dough especially bread (Bushuk & Rasper, 1994).

Gliadin and glutenin are two types of proteins inside the flour. The prolamins of wheat flour (gliadin) are extremely sticky and inelastic. It comprise of 40-50% of the proteins that is responsible for the cohesiveness of the dough. On the other hand, it also provides resistance to extension for the dough (Singh & MacRitchie, 2001). During the mixing, the prolamins and glutelins will combine together and forming an elastic protein gluten complex resulting more viscoelastic to the dough. The dough also has an ability to form thin sheets that able to produce a lighter baked product and retain the gas inside it (Gujral & Rosell, 2004).

Wheat flour can be made from the whole wheat or the germ. The bran can be separated from the endosperm is then ground into flour. Flour has a fewer nutrients if there is no fibrous bran and the oily germ in it but can produced a lighter textured and keep it longer. If the flour being kept for a longer period for about a month, the natural yellowish colour will fade to white colour due of oxygen. This can be eliminated by adding bleaching agents such as the benzoyl peroxide in it. Strong flour consists of protein in the range of 10.5%-14.5% and weak flour content less than 8.5% protein (Wongsagonsup, Kittisuban, Yaowalak & Suphantharika, 2015).

2.7.2 Salt

Salt, chemical compound, sodium chloride (NaCl) is considered as an important ingredient with functional role in production of bakery products. One of the function of salt as ingredient in the dough is to inhibit the yeast to down the rate of fermentation. Yeast dough without adding a salt in it is more sticky and hard to manipulate. In frozen dough products, adding salt delayed the fermentation process of yeast resulted slower down the production of carbon dioxide (Charley & Weaver, 1998).

Salt also helps to toughen and strengthen gluten that make the dough able to stretch easier then improved it quality and texture. A small amount of salt also can improve the flavor and favours the action of amylases in helping to maintain a supply of maltose as food for the yeast (Wood, 1989). The percentage of the salt added into the bakery formulas usually in the range of 1 to 25% of the flour weight (Collado-Fernandez, 2003). Salt do not have any presence of calories, proteins or carbohydrates but unrefined salt does contain traces of other minerals. Salt can help the kidneys to regulate the body's fluid levels and balance the acid and bases inside of human body (Whitney & Rolfes, 1996).

2.7.3 Sugar

Sugar was belongs to the group of nutrients that called carbohydrates. Sucrose is known as a disaccharide a composed of a unit of dextrose plus a unit of fructose. It is derived from the sugar cane or sugar beet, which has been refined and crystallised from a concentrated solution (Cauvain & Young, 2007). Normally sugar is used by yeast during the early stages of fermentation. Later, more sugars may be added to increase gas production in action of enzymes in the flour, to improve the crust colour and to sweeten the products. During baking, the reaction known as Maillard reaction occur when the reducing sugars combine with amino acids from protein in a complex reaction. That process gives an attractive brown colour on the surface of baked goods. The increasing in the concentration of the reducing sugars present, the darker the colour will be produced (Aljahdali & Carbonero, 2017).

According to Giannou *et al.,* (2003), sugars also act as anti-plasticizers retarding the pasting of native starch or function as anti-stale. Sugar inhibiting the starch recrystallization by delaying the gelatinization and the denaturation of protein as resulted can increase the shelf life of the product. Additions of sugar produce dough that is elastic, stable and softer besides, improved the crumb texture and moistness (Collado-Fernández, 2003). The addition of sugar level may reach as high as 30% of the flour weight. The gas producing ability of baker's yeast is affected by increasing the level of sugar. Addition of 15% sugar based on flour weight will have more than doubles the time that it would take for a piece of dough to reach a given height in the proofer (Cauvain & Young, 2006).

2.7.4 Fat and Oil

The importance of fats and oils as baking ingredients varies with the bakery product. Fat is added in the levels ranging from 2% to 8%. Different type of fats and oils are added into baked products to improve the volume, soften the texture and to have a uniform cell structure. It also helps in tenderizing effects upon the crumb and crust for the bakery products especially bread as well as to facilitate dough handling and processing. Fats also increase the caloric value that enhances the flavour and aroma of the products while stabilized the product much better. Presence of fat can promote enhanced recognition at the site of the taste buds because fat stays on the tongue longer (Kamel, 1992). However, vegetable oils or shortening are added to bakery products such as bread to avoid from getting stale, allowing it to be stored longer than period before being eaten.

2.8 Colour Measurement

Colour is an important quality attribute in the food as it cans influences consumer's choice and preferences to buy a product. Colour and appearance will attract a consumer to a product and can help in impulse purchases. Changes in expected colours can also indicate problems with processing or packaging. Judgement of food flavour is often influenced by colour; fruits such as cherry, raspberry and strawberry is associated with the colour of red (Vonelbe & Schwartz, 1996). In order to maintain quality, the colour of food products must be measured and standardized in it specific colour.

The Hunter Lab *L**, *a**, *b** and the modified CIE system called CIELAB colour scales are opponent-type systems commonly used in the food industry. The CIELAB coordinates (*L**, *a**, *b**) are directly read. It is considered the CIELAB uniform space in which two colour coordinates, *a** and *b** values, as well as a psychometric index of lightness, *L** value, are measured. The parameter *a** takes positive values for reddish colours and negative values for the greenish ones, whereas *b** takes positive values for yellowish colours and negative values for the bluish ones. The *L** value is an approximate measurement of luminosity, which is the property according to which each colour can be considered as equivalent to a member of the greyscale, between black and white. The CIELAB colour space has emerged as the predominant choice among researchers for objective colour measurement and analysis (Ngo *et al.*, 2007).

2.9 Texture Analysis

Texture comprises those properties of food stuff, apprehended by the eyes and by the muscle senses in the mouth including roughness, smoothness, graininess and others. Texture is an attribute that combining of physical properties such as the size, shape, nature and conformation of constituent structural elements of food. It perceived by the senses of touch, sight and hearing. Texture testing is a sub-area of rheology which is science that deals with the flow and deformation behavior of solid and fluid bodies under the influences of mechanical forces that being set. Texture is the total of all rheological and structural properties includes the geometric and surface-related properties of a food that being measured by mechanical tactile, visual and auditive receptors. The cell structure, size and form of the products also an important influence on the properties of the texture analyses (Winopal, Drobny & Schneider-Hader, 2015).

The viscosity is also one of the texture properties that showed the flow behavior of the fluid products. The viscosity of the food increase when the flow resistance increases. The flow resistance is when two fluid layers are pressed against each other. The mouth-feel describes how food behaves or analyses in the mouth. It covers on the texture properties that are perceived by feeling perceptions resulted on the pressure and contact in the mouth. One of the possible ways of analyzing the texture in food is by human sensory texture testing. The texture properties are described on the basis of terms used for the mouth-feel or finger-feel that depending on the sensory method. Examples of texture property are hardness, cohesion, stickiness and viscosity (Winopal, Drobny & Schneider-Hader, 2015).

Electronically controlled universal testing machine are machine that use a force sensor in recording the force that necessary in order to move a defined path in given time and also speed. Texture determine the chewability, adhesiveness, hardness and others properties of the food products. In the texture analyzer, there are various type of test can be done followed the type of the food itself. Such as compression test, penetration test, snapping test and extrusion test. Compression test is a test that used a flat probe lowered on the sample. The compression test usually used to test the firmness or the hardness of the products. Penetration test is a test that used smaller cylinder that pushed into the sample. The probe may be the cylinder, cone or ball. Other than that, the measurement for force required to snap a rigid food sample is known as snapping test. The bending force is generated until material snaps. It usually used with the snack chips and thin crisp products.

Then, the extrusion test is a test that applied force to sample until it flows through slots, holes or annual spaces. It is used to measure the firmness or tenderness of viscous materials such as gels and fats (Winopal, Drobny & Schneider-Hader, 2015).

2.10 Sensory Evaluation Test

Sensory evaluation is a scientific disciplines that analyses and measures human response to the composition and nature of foods. Sensory evaluation has been defined as a scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste, and hearing. The field of sensory evaluation has grown rapidly in the second half of the 20th century, along with the expansion of the processed-end food and consumer products industries (Krumbein, 2004). Nowadays, sensory evaluation becomes a tool irreplaceable in food industry while interacting with the key sectors in food production.

For effective sensory evaluation, the analyst should duly recognize the purpose of the study, select the appropriate experimental design, use panelists who fit the purpose, choose the proper method for preparing and presenting the samples, and analyze the data correctly (Meilgard, 1999). A sensory researcher should always consider whether the method is appropriately implemented and whether errors have been introduced at any stage of the experiment. Sensory evaluation methods may be divided into two broad classes namely affective and analytical methods. Affective methods require a much larger panel size than do analytical methods in order to have greater confidence about the interpretation of the results. The environment in which the sensory test is conducted should be carefully controlled, and samples must be prepared and presented in a uniform fashion so as not to influence panelists' perception of the food's quality (Krumbein, 2004).

2.11 Shelf Life of Food Product

The consumer's steadily growing requirements for the quality and the longer shelf life of foods and beverages. Hence, microbiologic testing of foods is an increasingly important aspect of microbiology. The microbiologic examination of food focuses on one of two principal techniques included the enumeration of bacteria present in a food and detection of specific bacteria or bacterial end products in a food sample (Bhuiyan *et al.*, 2010).

Enumeration usually is a quality index, relating either to the number of spoilage bacteria or the presence of indicator bacteria. Indicator bacteria are groups of bacteria that are associated with the presence of pathogenic bacteria. . They are used to indicate potential contamination because they are detected more easily and rapidly than specific pathogenic bacteria. Enumeration of the microorganisms present in a sample is normally performed by plate count method or the most probable number (MPN) method. The plate count method is based on culturing dilutions of sample suspensions in the interior or on the surface of an agar layer in a Petri dish. Individual microorganisms or small groups of microorganisms will grow to form individual colonies that can be counted visually (Farag *et al.*, 1989).

CHAPTER 3

METHODOLOGY

3.1 Materials

3.1.1 Raw Materials and Chemicals

This study was conducted at the Food Laboratory of Agro based Industry Faculty of Universiti Malaysia Kelantan (UMK) Jeli campus in Kelantan, Malaysia. Pumpkin, sugar, salt and butter were purchased from the local market in Jeli. Nutrient agar (MERCK) was obtained from the laboratory stock in university.

3.1.2 Equipment

The equipment that were used in this study were colour meter (Konica Minolta CR-400), Texture Analyzer (Brookfield CT3, USA), oven, electronic balance, hand mixer, sealed plastic bag, container, measuring cylinder, spoon, cutting board, tray, wire gauze, plastic bowl, flour siever, rolling pin, plastic glove, water and cookie cutter.

3.2 Methods

3.2.1 Preparation of Pumpkin Flour

The ingredients used were two ripe pumpkin (*Cucurbita mochata*) fleshes, 100g of sugar, 100g salt, 100 ml water and a block of butter for making dough of pumpkin cracker. For the preparation of pumpkin flour, the flesh of the pumpkin were sorted and washed with potable water while it seeds were removed. The fruit was cut into small and thin in sized. The prepared cut pumpkin fleshes were dried in dehydrator machine for 1 day in 60^0C temperature. The dried pumpkin fleshes then were grinded and sieved to get it in powder form.

3.2.2 Preparation of Pumpkin Cracker

Cracker samples were prepared in a straight dough process according to the recipe which the used of commercial all-purpose wheat flour (100 g), butter (6 g) sugar (10 g), salt (6 g) and water (45 ml). Pumpkin cracker was made at different level as shown in Table 1. All of the Ingredients were mixed into cohesive dough using the electrical hand mixer. Then, the dough was shaped in circle with 5cm diameter and 0.02 cm thick. The crackers were baked in an oven at 180^0C for 15 min. Baked crackers were then cooled at room temperature.

Table 3.2.2: Formulation of pumpkin cracker having different percentage of pumpkin flour

Pumpkin flour (%)	Ingredients / gram						
	Wheat Flour	Pumpkin Flour	Sugar	Salt	Butter	Water	Total (g)
0	100.0	0.0	10.0	6.0	6.0	45.0	161.0
20	80.0	20.0	10.0	6.0	6.0	45.0	161.0
30	70.0	30.0	10.0	6.0	6.0	45.0	161.0
40	60.0	40.0	10.0	6.0	6.0	45.0	161.0
50	50.0	50.0	10.0	6.0	6.0	45.0	161.0

3.2.3 Determination of Colour Attributes of Pumpkin Crackers

The instrumental measurement for the colour of pumpkin crackers product was carried out by using colour meter (Konica Minolta CR-400). All sample of the pumpkin cracker with different percentages were tested during four weeks of storage. The results from the colour of the pumpkin crackers were conveyed in the CIE L^* a^* b^* colour space. The data were recorded in triplicate.

3.2.4 Determination of Texture Attributes of Pumpkin Crackers

The texture of the pumpkin crackers were carried out by using the Texture Analyzer (Brookfield, CT3, USA) which used TPA test type, probe TA7, trigger load 5 g in a speed of 3.00 mm/s. The texture analyzer was focusing on the hardness, fracturability and cohesiveness of the pumpkin cracker. All data recorded in triplicate.

3.2.5 Sensory Evaluation

Sensory evaluation was a common tool in evaluating the general acceptability and quality attributes of the products. Sensory evaluation was carried out with 35 panelist involved of undergraduate students from Universiti Malaysia of Kelantan, Jeli, Kelantan. The testing was done in Food Laboratory of Jeli Campus. Each panelist was served with 5 samples of pumpkin crackers. Plain water is provided for mouth rinsing between samples. Attributes of pumpkin cracker product tested are colour, aroma, flavour, taste and overall acceptance. The pumpkin cracker product is evaluated using the 7-points hedonic scale depicted on the score sheet below.

Table 3.2.5: Hedonic scale rating for sensory evaluation

Likeness	Sensory Score
Like Very Much	7
Like Moderately	6
Like Slightly	5
Neither Like Nor Dislike	4
Dislike Slightly	3
Dislike Moderately	2
Dislike Very Much	1

3.2.6 Shelf Life of the Pumpkin Cracker during Storage

The shelf life of pumpkin cracker was determined by using microbiological analysis technique. The best sample from sensory evaluation was analysed for the total bacterial load using the plate count agar by spread plate technique according to Taniya (2016). One gram of the pumpkin cracker sample for different ratio was mixed with 9 ml sterile diluent and from this suspension, three serial, 1/1000 dilutions are made and 0.1 ml is spread on plate count agar from each dilution. The plate is made in triplicate and is incubated at 37°C which was room temperature in four weeks and being observed for every week. The colonies are monitored and counted within storage time. The count is expressed as cfu/g.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Colour Attributes of Cracker Incorporated with Pumpkin Flour during Four Weeks of Storge

Colour changes for the cracker incorporated with pumpkin flour during four weeks of storage is shown by the chromatic parameters (L^*, a^*, b^*) in the bar graph below. L^* stand for the lightness, a^* is for redness and b^* is for yellowness of the pumpkin cracker.

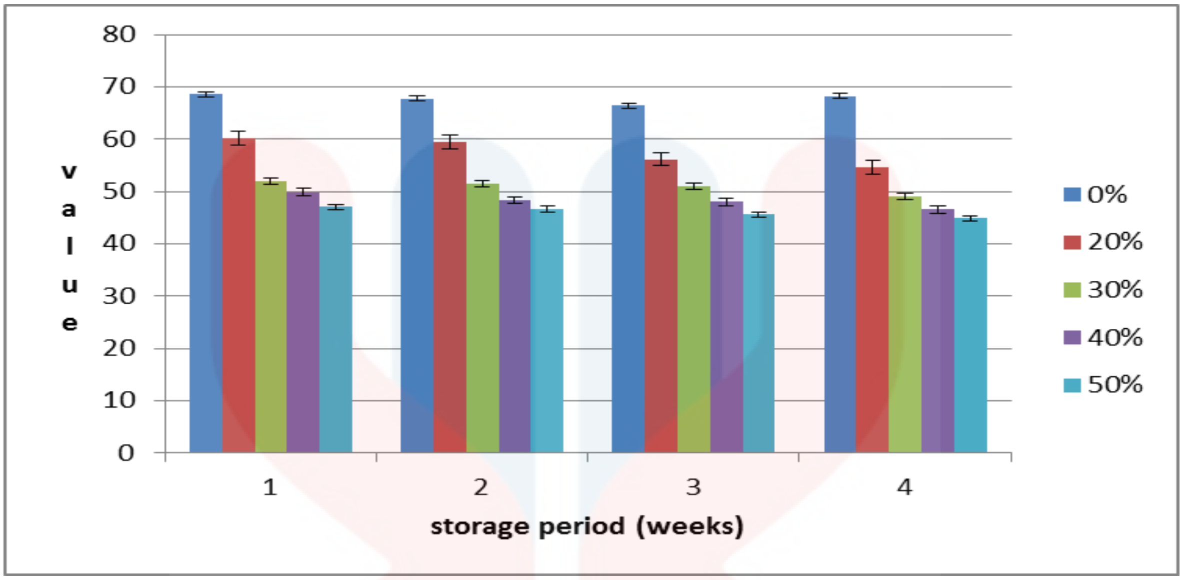

Figure 4.1 (a): Value for the lightness ($L*$) of the cracker of different percentage of pumpkin flour during four weeks of storage.

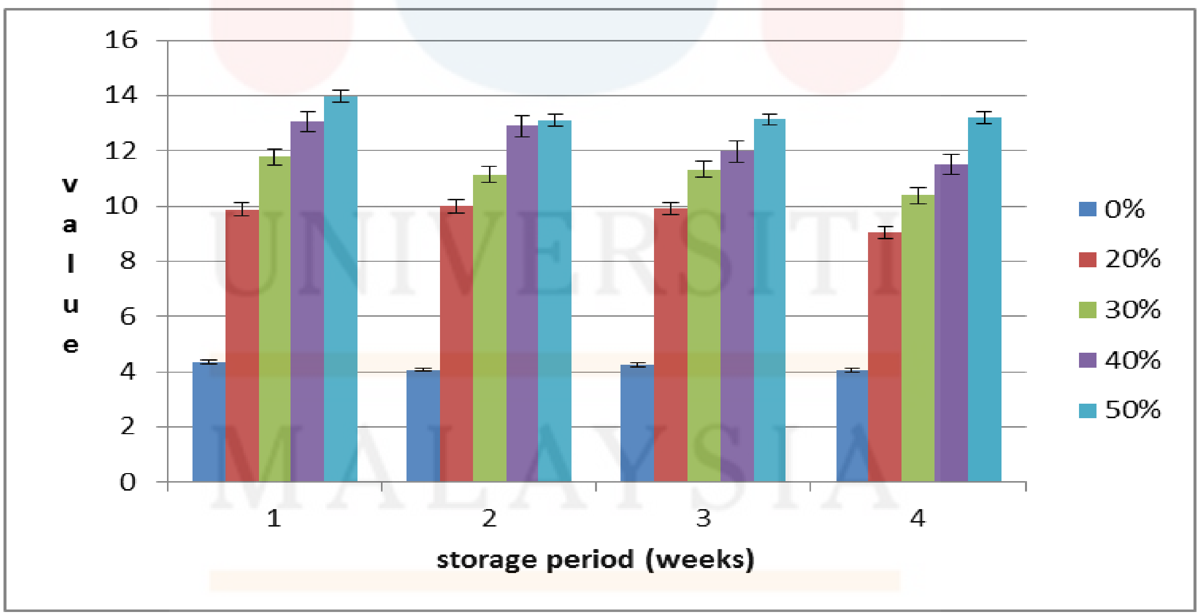

Figure 4.1 (b): Value for the redness ($a*$) of the cracker of different percentage of pumpkin flour during four weeks of storage.

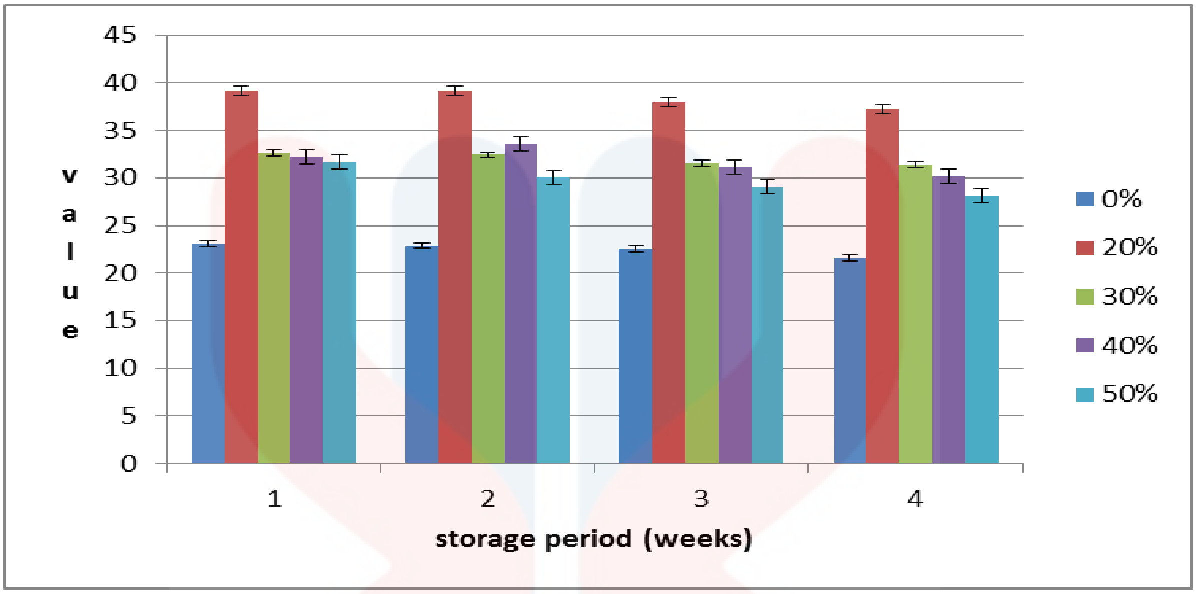

Figure 4.1 (c): Value for the yellowness (*b**) of the cracker of different percentage of pumpkin flour during four weeks of storage.

Lightness (*L**) is the perception by which white objects are distinguished from gray and the light colour objects from the dark colour. The result from the study showed that the higher the percentage of flour substitution with pumpkin, the lightness intensities had a decreasing trend value from 68.57 to 47.04 for control and 50% respectively. It showed that the colour of the pumpkin cracker had change from the brighter colour to yellowish brownish colour as higher level of the pumpkin flour substitute in the cracker. The changes of lightness value of the cracker might be due to the non-enzymatic browning or Maillard reaction of pumpkin. It might be occurred during the cracker processing and also storage for extended period. For the products that had higher concentrations of sugar, they can combine with the amino acid or become one of the parts in protein chains to form dark compounds (Sabeera, Baba, Nazir, Masoodi, Bhat & Bazaz, 2016). The lightness of the cracker also became decreased during storage.

The redness of the pumpkin cracker is showed by *a** value. The redness of the pumpkin cracker had an increasing value when the percentage of the pumpkin flour substitution increased. The result from the Figure 4.1 (b) showed that the value for control was 4.33 changes to 13.97 with pumpkin flour of 50%. The darker colour of the cracker was observed in cracker that contain the highest value of pumpkin flour (50%) as indicated by lower value of *L**. The change of redness value was perhaps attributed to the presence of Maillard reactions during the high temperature in baking (Jagadeesh, Basavaraj, Reddy & Swamy, 2007). Within the time storage of four weeks, the redness values of the pumpkin cracker also tend to decrease in slow rate.

The decreasing of value of the yellowness (*b**) is showed in the Figure 4.1 (c). The value of *b** showed a decreasing trend (39.19-31.63) in increasing level of the pumpkin flour substitution in the cracker. During storage of four weeks, the yellowness values of the pumpkin cracker also tend to decrease. This might be due to the degradation of the carotene pigment take place that responsible in decreasing of the yellowness of pumpkin cracker. Pumpkin has a large amount of carotenoids especially in it pulp. Carotenoids that contains in the pulp of the pumpkin has a double bond in carbon chain that make it capable to some reaction during food storage and processing that can cause to degradation of colour such as oxidation and isomerization. Hence, the occurrence of non-enzymatic browning reactions that also took place together with oxidation and isomerization of beta-carotene change the colour parameters of pumpkin cracker (Sabeera, 2016).

4.2 Texture Properties of Cracker Incorporated with Pumpkin Flour during Four Weeks of Storage

Texture refers to the physical attributes of the food that processed by brain during mastication. Texture analysis test that was focused on this study were the hardness, fracturability and cohesiveness of the pumpkin cracker during four weeks of storage period. The results were shown in a bar graph below.

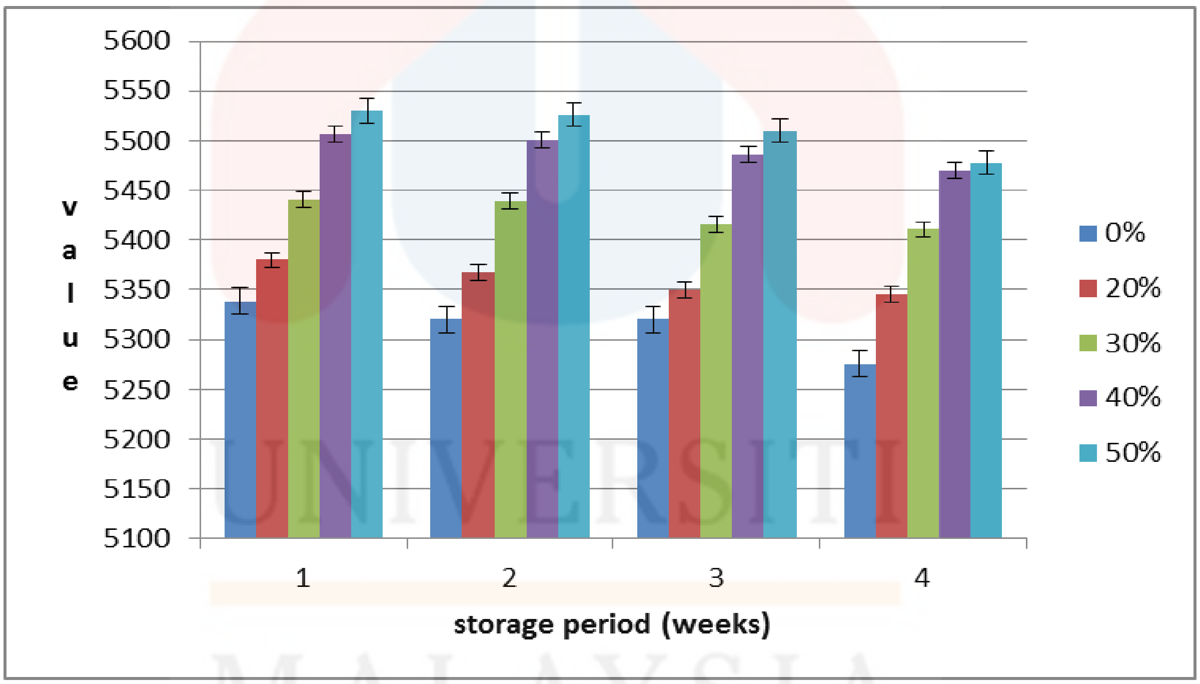

Figure 4.2 (a): Value of the hardness attribute for the crackers incorporated with pumpkin flour.

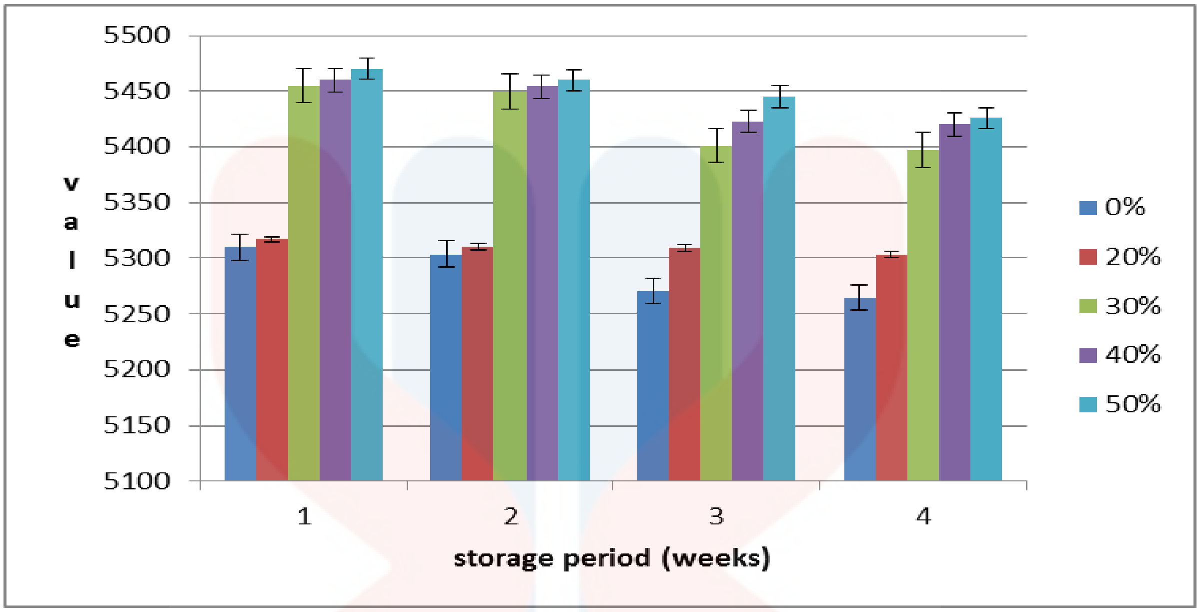

Figure 4.2 (b): Value of the fracturability attribute for the crackers incorporated with pumpkin flour.

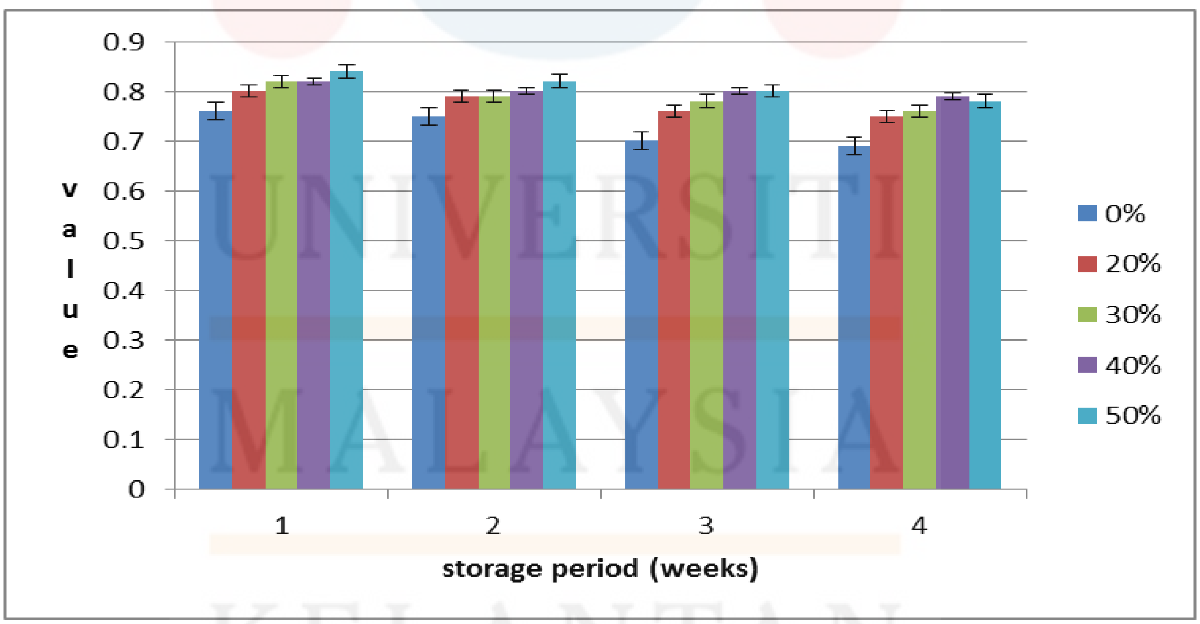

Figure 4.2 (c): Value of the cohesiveness attribute for the crackers incorporated with pumpkin flour.

Hardness is the force required for compressing completely a sample between the molars. Measure the resistance of a product to deformation or rupture. It is mechanical textural attribute relating to the force required to compress the sample (Di Monaco, Cavella & Masi, 2007). The hardness of the pumpkin cracker showed an increasing trend (5380-5530) when the pumpkin flour substitution increase. The highest value for the hardness attributes was on 50% of pumpkin flour substitution in the cracker. In increasing of the time storage, the result showed decreasing trend for each of the pumpkin cracker.

Fracturability is the ability to break food into pieces when it is bitten using the incisors (Paula & Conti-Silva, 2014). The result of the fracturability also tends to increase within the increasing of percentage of pumpkin flour. The higher results were scored by three type of pumpkin cracker (30%, 40% and 50%) with the highest was 50% which was 5470. The result of fracturability value was decreased when time of storage increase from week one to week four. Then, Cohesiveness is the mechanical textural attribute relating to the degree to which a food can be deformed before breaks (Di Monaco *et al.*, 2007). The higher the level of cracker substitution with pumpkin flour, the cohesiveness showed an increasing trend (0.76-0.84) from week one to week four and the values tend to decrease with increasing of the time storage.

Starch is main storage carbohydrate in the early stages of fruit development that degraded with the onset of ripening of fruit (Sonu Sharma & Ramana Rao, 2013). As stated by Saeleaw and Schleining, pumpkin flour contains a high level of carbohydrates (79.57%) and starch (48.30%) that can be used as thickener in fabricated snacks and ingredient in bakery product. In baking, no gluten or very little gluten is required because gluten is used in leading to tougher products without shortness. The present of starch in the pumpkin flour was useful in gelatinization and pasting characteristics for the cracker which can improve the quality and texture of the cracker. The starch granule swells and absorbs water to become functional (Saeleaw & Schleining., n.d). When the pumpkin flour was placed into the dough, it makes the dough to be more thick and viscous. The hardness, fracturability and cohesiveness attributes mainly affected by the present of starch as the thickener for the cracker. Because of that, higher amount of pumpkin flour used would increase that three attributes values for the cracker.

4.3 Sensory Acceptability of Cracker Incorporated with Pumpkin Flour

Consumer acceptance for the pumpkin cracker was showed in the table below. The attribute that was observed were colour, aroma, flavour, taste and overall acceptance of the pumpkin cracker.

Table 4.3 (a): Score values from sensory evaluation in mean and standard deviation (SD)

	Attributes				
Pumpkin Flour (%)	Colour (mean±SD)	Aroma (mean±SD)	Flavour (mean±SD)	Taste (mean±SD)	Overall (mean±SD)
0%	2.69 ± 0.76	2.94 ± 0.87	3.51 ± 0.89	3.57 ± 0.56	4.49 ± 0.61
20%	5.40 ± 1.06	4.71 ± 0.82	5.00 ± 0.91	4.94 ± 0.71	5.23 ± 0.81
30%	4.71 ±0.99	4.29 ± 0.62	4.51 ± 0.78	4.29 ± 0.57	4.40 ± 0.65
40%	4.49 ± 0.89	4.43 ± 0.85	4.26 ± 0.61	4.23 ± 0.81	3.91 ± 0.70
50%	4.37 ± 0.69	4.17 ± 0.89	4.31 ± 0.68	3.34 ± 0.76	3.60 ± 0.81

Table 4.3(b): Score values from sensory evaluation in one-way ANOVA

Attributes	Groups	Sum of Squares	df	Mean Square	F	Significance
Colour	Between Groups	59.863	4	14.966	11.838	0.000
	Within Groups	214.914	170	1.264		
	Total	274.777	174			
Aroma	Between Groups	23.166	4	5.791	6.320	0.000
	Within Groups	155.771	170	0.916		
	Total	178.937	174			
Flavour	Between Groups	19.737	4	4.934	6.746	0.000
	Within Groups	124.343	170	0.731		
	Total	144.080	174			
Taste	Between Groups	45.006	4	11.251	20.561	0.000

	Within Groups	93.029	170	0.547		
	Total	138.034	174			
overall	Between Groups	38.777	4	9.694	15.899	0.000
	Within Groups	103.657	170	0.610		
	Total	142.434	174			

A new developed product needs a correct measurement of the sensory evaluation and good in understanding of an acceptance pattern of the consumers regarding the product (Yang & Moon, 2011). The new product that need to be market need to be ensured that it will be accepted by the consumers itself regarding it certain criteria. Sensory evaluation can be described as a method or test that is used to evoke, measure, analyse and interpret responses through the five senses of human which are sight, smell, touch, taste and hearing. Sensory evaluation characteristics include the aroma, flavor, taste, texture and colour.

From sensory evaluation test, colour, aroma and flavour of the cracker incorporated with pumpkin flour is more preferable rather than control. For colour attributes, all of the crackers incorporated with pumpkin flour got highest value than the control (0% of pumpkin flour). The colour of the cracker was influenced by the presence of carotenoids inside of the pumpkin flesh that give yellow to orange range colour (Zhou *et al.*, 2007).

This showed that colour attribute of the food product play a main role in increase the consumer preference towards the product. it has been proved that colour give strong effect on perception toward customers and the right choice of colour need to be identified due to it important factors in creating the consumers first impression through product selection (Gofman, 2010). The most prefer pumpkin cracker colour is the 20% of pumpkin flour used which is 5.4±1.06. This showed that the best colour result for the pumpkin cracker is on 20% of pumpkin flour. The higher the substitution of pumpkin flour to the cracker, made the preference of the consumer decrease from 5.40 to 4.37.

In aroma, the cracker incorporated with pumpkin flour got higher value compared to the control. This might be due to the addition of pumpkin as the ingredient of the cracker gave an aroma of vegetables that made it smell good and increase the consumer acceptability. The highest value for the aroma was on the 20% of pumpkin flour (4.71±0.82). From the score value, it showed that the cracker with the aroma of pumpkin is acceptable by the consumer due to the highest score for each of the crackers rather than the aroma of the original (2.94±0.87) one. The flavour of the pumpkin as added value in the cracker was acceptable by the consumers due to the higher value in each of the cracker compared to 0% of pumpkin flour. The highest score for the flavour was on cracker incorporated with 20% of pumpkin flour (5.00±0.91). The pumpkin flour gives the cracker a sweet vegetable flavour to the consumers that make it one of the factors of preference from the consumer (Anju, Sharma & Surekha, 2009).

For the taste of the pumpkin cracker, the ratios that were preferable were 20% (4.94), 30% (4.29) and 40% (4.23) of pumpkin flour substitution but on 50%, the score became lower than the control which was 3.34. This showed that the preferred taste level from the consumer for the pumpkin cracker is limit on 40% of pumpkin flour. When higher percentage of pumpkin flour substitution than that value it will make the degree of likeness of the consumers become decrease. Therefore, the addition of the pumpkin flour into the food products would enhance the product colour, aroma, flavour and taste that made improvement on the product itself and also to the consumer acceptance.

4.4 Microbial Content of Cracker Incorporated with Pumpkin Flour during Four Weeks of Storage

Table 4.4: The number of colony counting for 20% of pumpkin flour in cracker during four weeks of storage

Week	Colony Counting
1	1
2	2
3	5
4	7

The Total Plate Count (TPC) result the microorganism growth in a product and it also can be used to measure the quality and level of spoilage of the product within certain storage of time. Estimating the number of microorganisms in a food product will indicate the shelf life of the product due to the present of microorganism can cause to the spoilage of the food itself and decrease it shelf life. TPC is a test in counting the viable bacteria in colonies grown that being observed on the plate count agar plate. Colony forming unit (CFU) was used in determining the colony and the range of suitable colony counting is 25 to 250.

In the present study conducted, the result of Total Plate Count (TPC) counts in the sample of highest score of acceptance for the cracker from the consumer which was 20% of pumpkin flour substitute. The test was done in four weeks of storage in a room temperature incubator. The resulted that had being observed showed that the microbial load increase in increasing of storage time from 1 to 7 colony but it was counted as zero due to less than 25 colony in colony counting.

The lower number observed in the sample for TPC might be due to the intrinsic factor of the cracker. Pumpkin cracker had a lower of water activity (a_w) that makes it lower in moisture content that retards the growth of the microbial on it. According to Banwart (1979), the optimum growth level for water activity of most microorganisms is from 0.97-0.99 in a_w value. For the cracker, the approximate a_w level is 0.10 which was too low for the microorganism to growth on the cracker. Control of mold growth in bakery products usually depend on maintaining the water activity or moisture contain in a low condition. However, low water activity can affected the quality and might be cause changes in texture and shape of the bakery products (Seiler, 2000).

The processing factor which include the drying and heating method of the pumpkin cracker also affect the types and numbers of the microbial that exist inside of the food products (Hamad, 2012). Temperature also plays an important role in mold growth and in the germination of the spores. The temperature range 18.3-29.4^{o}C and when bakery products temperature reduced until optimum temperature was the usually temperature for molds to growth (Saranraj & Geetha, 2012). The baking process that is used of higher temperature which was 180^{o}C can kill and retard some of the microorganisms due to the temperature that is higher than 100^{o}C and lead to increasing the shelf life of the pumpkin cracker.

CHAPTER 5

CONCLUSION

Throughout the whole study of pumpkin cracker with different percentage, it can be concluded that the lightness, redness and yellowness intensities for all percentages of pumpkin cracker have increased within the increasing of pumpkin flour substitution but decreased with increasing of storage time. The main factor that affected the colour of the pumpkin cracker was the existence of carotenoids inside of the pumpkin flesh that give a yellowish brownish colour to the cracker. It also can act as a natural colouring for food product.

The texture of the cracker in the term of hardness, fracturability and cohesiveness also had an increasing trend in increasing of pumpkin flour used but decreased within the time storage from week one to week four. The texture of the pumpkin cracker is mainly affected by the carbohydrates and starch composition inside of the pumpkin. The starches give the cracker more thick and viscous in the shape and texture.

The one-way ANOVA test showed that consumer more prefer cracker with pumpkin substitution and had higher acceptability among consumers especially 20% of pumpkin flour substitution in cracker. It is to be recommended that the cracker with 20% of substitution of pumpkin flour would be the most suitable to be consumed or marketed. It had received a highest score for all of attributes colour, aroma, flavour, taste and overall acceptance. The highest substitution of pumpkin flour in the cracker will lower the consumer acceptability.

The pumpkin cracker also had a longer shelf life due to less number of microbial growths within four weeks of storage. This is due to the lower water activity and higher temperature applied during baking of the cracker. The study could be extended for a research on microbiological quality, economic feasibility and also nutritional value in the pumpkin cracker.

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APPENDIX A

Table A.1: Colour analysis value of pumpkin cracker with different percentage of pumpkin flour within four weeks of storage

Weeks	Pumpkin Flour (%)	Colour Analysis		
		*L** (mean ± SD)	*a** (mean ± SD)	*b** (mean ± SD)
1	0%	68.57 ± 2.52	4.33 ± 0.22	23.06 ± 1.29
	20%	60.16 ± 0.73	9.88 ± 0.16	39.19 ± 1.04
	30%	51.97 ± 2.23	11.78 ± 0.61	32.65 ± 0.31
	40%	49.86 ± 1.34	13.06 ± 0.81	32.20 ± 3.44
	50%	47.04 ± 0.81	13.97 ± 0.06	31.63 ± 3.72
2	0%	67.77 ± 0.59	4.07 ± 0.06	22.89 ± 0.19
	20%	59.56 ± 1.36	9.98 ± 0.10	39.13 ± 0.50
	30%	51.43 ± 1.94	11.13 ± 0.10	32.44 ± 0.54
	40%	48.31 ± 0.52	12.89 ± 0.46	33.62 ± 1.39
	50%	46.63 ± 0.35	13.90 ± 0.25	30.00 ± 0.90
3	0%	66.43 ± 0.59	4.24 ± 0.24	22.59 ± 1.29

	20%	56.18 ± 0.50	9.90 ± 0.12	37.98 ± 0.54
	30%	51.05 ± 1.16	11.33 ± 0.40	31.56 ± 0.95
	40%	47.97 ± 0.87	11.97 ± 0.33	31.17 ± 0.96
	50%	45.63 ± 0.67	13.13 ± 0.60	29.03 ± 0.75
4	0%	68.24 ± 1.64	4.06 ± 0.14	21.59 ± 1.23
	20%	54.68 ± 0.61	9.04 ± 0.56	37.22 ± 0.58
	30%	49.16 ± 0.38	10.38 ± 1.08	31.39 ± 0.35
	40%	46.51 ± 0.56	11.50 ± 0.48	30.21 ± 0.39
	50%	44.85 ± 1.01	13.19 ± 0.16	28.09 ± 0.79

Table A.2: Texture analysis value of pumpkin cracker with with different percentage of pumpkin flour within four weeks of storage

Weeks	Pumpkin Flour (%)	Hardness (mean ± SD)	Fracturability (mean ± SD)	Cohesiveness (mean ± SD)
1	0	5339 ± 0.38	5310 ± 0.23	0.76 ± 0.005
	20	5380 ± 53.29	5317 ± 0.48	0.80 ± 0.01
	30	5440 ± 1.00	5455 ± 0.45	0.82 ± 0.006

	40	5506 ± 0.62	5460 ± 0.38	0.82 ± 0.01
	50	5530 ± 0.57	5470 ± 0.39	0.84 ± 0.01
2	0	5320 ± 0.43	5304 ± 0.26	0.75 ± 0.001
	20	5367 ± 0.22	5310 ± 0.22	0.79 ± 0.001
	30	5438 ± 2.26	5450 ± 0.51	0.79 ± 0.004
	40	5500 ± 0.73	5454 ± 0.32	0.80 ± 0.02
	50	5525 ± 0.88	5460 ± 0.35	0.82 ± 0.006
3	0	5319 ± 0.58	5271 ± 0.19	0.70 ± 0.01
	20	5350 ± 1.03	5309 ± 0.24	0.76 ± 0.02
	30	5416 ± 0.35	5401 ± 0.34	0.78 ± 0.01
	40	5548 ± 0.33	5423 ± 0.06	0.80 ± 0.006
	50	5510 ± 0.57	5445 ± 0.22	0.80 ± 0.006
4	0	5276 ± 0.45	5265 ± 0.3	0.69 ± 0.01
	20	5345 ± 0.18	5303 ± 0.36	0.75 ± 0.006
	30	5411 ± 0.40	5397 ± 0.35	0.76 ± 0.006
	40	5470 ± 0.14	5420 ± 0.28	0.79 ± 0.006
	50	5478 ± 0.22	5426 ± 0.25	0.78 ± 0.006

Table A.3: One-way ANOVA for sensory evaluation

		Sum of Squares	df	Mean Square	F	Sig.
colour	Between Groups	59.863	4	14.966	11.838	.000
	Within Groups	214.914	170	1.264		
	Total	274.777	174			
aroma	Between Groups	23.166	4	5.791	6.320	.000
	Within Groups	155.771	170	.916		
	Total	178.937	174			
taste	Between Groups	19.737	4	4.934	6.746	.000
	Within Groups	124.343	170	.731		
	Total	144.080	174			
appearance	Between Groups	45.006	4	11.251	20.561	.000
	Within Groups	93.029	170	.547		
	Total	138.034	174			
overall	Between Groups	38.777	4	9.694	15.899	.000
	Within Groups	103.657	170	.610		
	Total	142.434	174			

APPENDIX B

Figure B.1: Dried Pumpkin

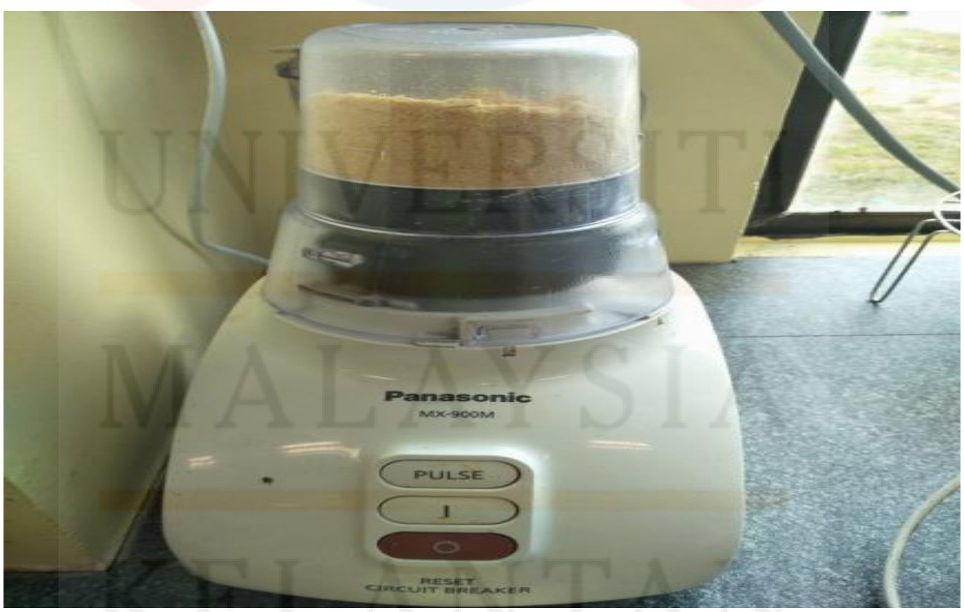

Figure B.2: Grinding process

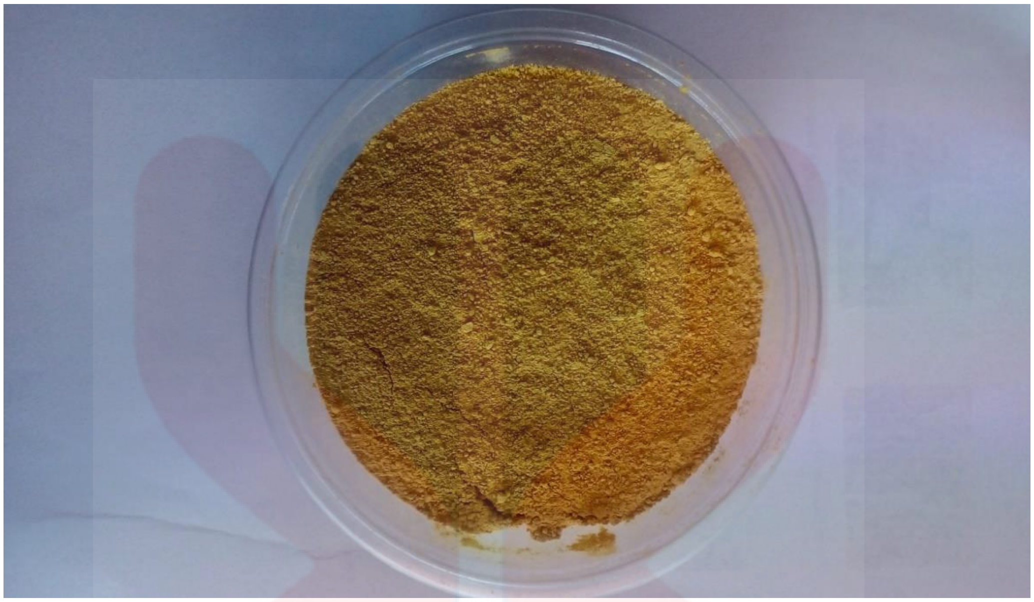

Figure B.3: Pumpkin flour

Figure B.4: Control cracker (0% pumpkin flour)

Figure B.5: Pumpkin Cracker with 20% substitution

Figure B.6: Pumpkin cracker with 30% substitution

Figure B.7: Pumpkin cracker with 40% substitution

Figure B.8: Pumpkin cracker with 50% substitution