



**UNIVERSITI PUTRA MALAYSIA**

***TEXTURAL QUALITY OF WAFFLE ICE CREAM CONE FROM SWETT  
POTATO PEEL FLOUR***

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POTATO PEEL FLOUR**

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## ABSTRACT

Sweet potato (*Ipomoea batatas*) are the nutritious vegetables found in Malaysia. However, there about 15 to 40% of sweet potato peel waste has been found in the sweet potato industry. The sweet potato peel rich in nutritional values such as carbohydrates which act as the main source of energy for the body. In this study, the sweet potato peel processed into a flour for the used in the application in food products. The sweet potato peel flour (SPPF) being used in the substitution of wheat flour in the batter formulation of the making of waffle ice cream cones. There are four different samples of waffle cones which are control, 5% SPPF, 10% SPPF and 15% SPPF waffle cones. The result of the proximate analysis, the sweet potato peel flour (SPPF) rich in carbohydrate which reached 47.38%. Sweet potato peel flour also high in WHC and OHC by 295.94% and 329.97% respectively.  $L^*a^*b^*$  colour analysis has shown that the increasing amount of SPPF increasing the darkness of the waffle cones. The texture analysis resulted 5% SPPF waffle cones had the highest crispiness of waffle cones. The waffle cones have been analyzed and shown that it has a longer shelf life by maintaining the colour of waffle cones and the waffle cones free from any growth of microorganisms. The overall acceptability from the sensory evaluation, that the 5% SPPF waffle cones chosen as the best acceptance of waffle cones. This sweet potato peel flour (SPPF) could be used for other application in the food products due to high water and oil holding capacity where it can be used for the making of viscous food and the meat-based product. In conclusion, the 5% SPPF successful in the making of waffle cones but due to its high and oil holding capacity, it can be used for the making of another applications in food products.

**Keywords:** Sweet potato peel, sweet potato peel flour, sweet potato peel waffle cones.

## ABSTRAK

Ubi keledek (*Ipomoea batatas*) adalah sayur-sayuran berkhasiat yang terdapat di Malaysia. Walau bagaimanapun, sekitar 15 hingga 40% sisa kulit ubi keledek telah dijumpai di kawasan industri. Kulit ubi keledek kaya dengan khasiat makanan seperti karbohidrat sebagai sumber tenaga utama untuk tubuh badan manusia. Dalam kajian ini, kulit ubi keledek telah diproses menjadi tepung untuk menghasilkan produk makanan. Tepung kulit ubi keledek (SPPF) digunakan sebagai pengganti tepung gandum dalam formulasi adunan pembuatan kon wafel ais krim. Terdapat empat sampel wafel kon yang berbeza digunakan iaitu kawalan, 5% SPPF, 10% SPPF dan 15% SPPF kon wafel. Hasil analisis, tepung kulit ubi keledek (SPPF) kaya dengan karbohidrat yang mencapai 47.38%. Analisis warna  $L^* a^* b^*$  menunjukkan bahawa peningkatan jumlah SPPF yang digunakan meningkatkan kegelapan kon wafel. Analisis tekstur menunjukkan wafel kon 5% SPPF mempunyai kerangupan kon wafel yang paling tinggi. Kon wafel dianalisis dan ditunjukkan bahawa ia mempunyai jangka hayat yang lebih lama dengan mengekalkan warna kon wafel dan kon wafel bebas dari sebarang pertumbuhan mikroorganisma. Penilaian deria menunjukkan bahawa 5% SPPF kon wafel dipilih sebagai penerimaan terbaik dari kon wafel. Tepung kulit ubi keledek (SPPF) ini dapat digunakan untuk menghasilkan produk makanan yang lain juga kerana daya tahan air dan minyak yang tinggi di mana ia dapat digunakan untuk pembuatan makanan kental dan produk berasaskan daging. Kesimpulannya, SPPF 5% berjaya dalam pembuatan kerucut wafel tetapi kerana daya tahannya yang tinggi dan minyak, ia dapat digunakan untuk pembuatan aplikasi lain dalam produk makanan.

*Kata kunci:* Kulit ubi keledek, tepung kulit ubi keledek, wafel kon.

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## **LIST OF ABBREVIATION**

**SPPF – Sweet potato peel flour**

**H<sub>2</sub>SO<sub>4</sub> – Sulphuric acid**

**HCl – Hydrochloric acid**

**WHC – Water holding capacity**

**OHC – Oil holding capacity**



## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant that belongs to the morning glory family, Convolvulaceae. Sweet potato is widely grown throughout the tropics and warm temperature regions of the world. It is very valuable because of its short growing period from 90 days to 120 days which is an important crop for the developing countries (Mohd Hanim, Chin, & Yusof, 2014). Sweet potato is high in nutritional value including fiber, carbohydrate high value of protein which is healthy nutrient needs by the human body.

In Malaysia, sweet potato ranks the second popular of tuber crops next to cassava (Mohd Hanim et al., 2014). There are a few varieties of sweet potato available in Malaysia including *Batang Merah*, *Kangkong*, *Senduduk Kulit Putih*, *Senduduk Kulit Merah*, *Mahsuri* and *VitAto* (Izalin, Zahari, Meriam, Dan, & Hassan, 2014). Orange-fleshed sweet potato tubers have been utilized as food in their fresh form after cooking, as flour and in the grated and mashed forms. The roots of the orange-fleshed sweet potato rich in

provitamin A carotenoids than other sweet potato varieties including the cream and white-fleshed varieties (Owade, Abong, & Okoth, 2018).

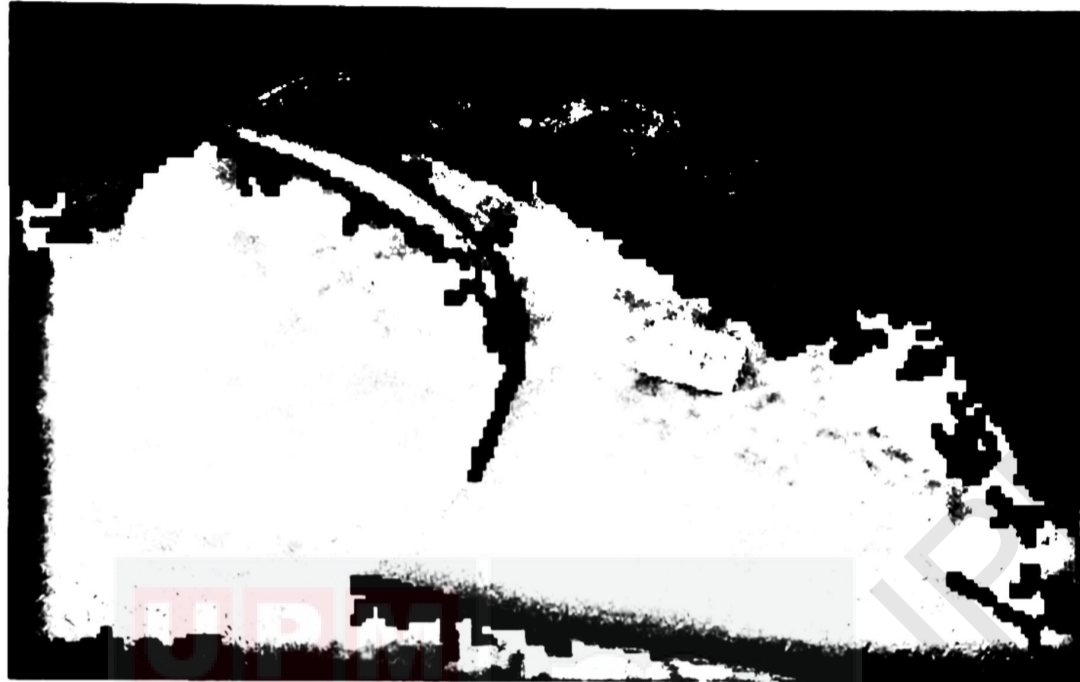


Figure 1.1 – Orange-fleshed sweet potato

An orange-fleshed sweet potato contains a high value of  $\beta$  – carotene content and antioxidant compounds such as vitamin C, E and anthocyanin (Yahya, Abdullah, & Tajarudin, 2016). The nutritional value content in the sweet potato is very good for our health by slowing the aging process, prevent cancer and reduce the cholesterol content in the blood. Besides, sweet potato also contained fiber which is beneficial for diabetes patients who need a healthy lifestyle. Approximately 77% of the fibers in the sweet potato are insoluble and they have their role in fighting against diabetes. Insoluble fibers are essential in promoting insulin sensitivity which helps in regulating the amount of sugar in the blood.

Sweet potato is very synonymous to the Malay community as the main ingredients in making traditional *kuih-muih* such as *cek mek molek*, *onde-onde*, *bingka* and *keria*. But

people nowadays are less interested in the traditional dessert since they are more interested in bakery products such as biscuits, muffins and cakes. To retain the value of the sweet potato in the market, an initiative has been created as sweet potato is rich in nutritional value.

Processing the sweet potato into flour is the most satisfactory method in creating a nutritional product with a stable shelf life that can extend the period without spoilage. Producing the sweet potato flour is one of the alternative ways to diversify the new product from sweet potato and increase the revenue of farmers and processors, then increase the economy.

In this study, sweet potato peel waste has been utilized as one of the ingredients in the making of waffle cones for ice cream in the substitution of sweet potato peel flour in the batter formulation. Sweet potato peel is edible and has high potential application as a healthy food product where it is a good source of  $\beta$ -carotene, fiber, polyphenols and other good compounds that give various beneficial effects to the human health. Sweet potato peel flour can be used to replaced wheat flour since sweet potato itself contains fiber which very suitable for the diabetes patients. Thus, the sweet potato peel is very suitable to be reuse instead of throwing it to the dustbin and become a waste.

The objectives of this project are to study the nutritional value of the sweet potato peel flour and the texture analysis of the waffle cones including the hardness, brittleness, toughness and crispiness. Colour of the food product will define the acceptance of the food and also can be an attraction factor of consumers towards the food. The strength of the food also needs to be considered because it will affect the handling and storage process of the food product which is the waffle cone.



## **1.2 Problem Statement**

- i. Due to increasing the number of populations and rising incomes of people living in a developing countries, the demand for processed food also increased (Maria & Freire, 2010). .Potato chips are the most common food processed product which produces a large amount of peel as the by-products (Stearns et al., 1994).**
- ii. Most of the sweet potato processing industry only used the sweet potato flesh in producing the food product. The peel will be thrown away and become a waste.**
- iii. There were about 15 to 40% of sweet potato peel waste found in the industrial of sweet potato processing, depending on the peeling method (Sepelev & Galoburda, 2015). From other data, it found that the global amount of sweet potato waste in 2011 accounted for about 7% of the entire crop (FAO, 2016).**
- iv. An increasing number of waste from the industry increasing the number of waste in the landfill which can lead to the environmental problem. Sweet potato peel is edible and has a good nutritional value for human health as the people nowadays are very concern to have a healthy lifestyle.**
- v. To encounter the problem, the sweet potato peel has been utilized into new functional food products.**

### **1.3 Objectives**

The objective of this project are:

- i. To analyze the proximate analysis of sweet potato peel flour.
- ii. To analyze the textural properties of waffle cone come from sweet potato peel flour (SPPF).
- iii. To evaluate the sensory analysis of the sweet potato peel flour (SPPF) waffle cones.

### **1.4 Scope of the Study**

This study is to investigate the nutritional content in the sweet potato peel flour which benefits human health and the texture analysis of the waffle cones which the sweet potato peel flour being used as the ingredients for the making of waffle cones. This study focusing on the benefit of the sweet potato peel. The sweet potato peel choose is from the orange-fleshed sweet potato variety which rich in nutritional value for human health.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter provides a review of the research and is divided into three main sections. Section 2.2 is an overview of choosing the orange-fleshed sweet potato, section 2.3 overview on the sweet potato peel flour and the last section which is section 2.4 is an overview of the waffle cones.

#### **2.2 Overview of Orange-fleshed Sweet Potato**

##### **2.2.1 Background and history of orange-fleshed sweet potato**

Sweet potato is a member of the family Convolvulaceae. Sweet potato (*Ipomoea batatas*) are highly nutritious vegetables that are rich in nutrient and active phytochemicals such as  $\beta$ -carotene, polyphenols, ascorbic acid and dietary fiber (Van Hal, 2000). Sweet potato is widely grown up in the tropical and warm climate in the world. It is valued and become an important crop in developing countries for its sort growing period of 90 to 120 days (Mohd Hanim et al., 2014). There are many types of sweet potato found which are

purple-flesh sweet potato, orange-fleshed sweet potato and white-fleshed sweet potato. Besides, each type of sweet potato consists of many types of variety.

Example of sweet potato variety found in Malaysia are *Batang Merah*, *Kangkong*, *Senduduk Kulit Putih*, *Senduduk Kulit Merah*, *Jepun*, *Mahsuri* and *VitAto* (Izalin et al., 2014).



Figure 2.1 – Orange-fleshed Sweet Potato

The sweet potato is commonly used as the main ingredients in the making of 'kuih-muih' such as cek mek molek, onde-onde, bingka and keria. However, people nowadays had less interest in that traditional food and more interest in bakery products such as biscuits, muffins and cakes.

The orange-fleshed sweet potato has been processed in production the sweet potato flour and being used as the pre-mixed flour for the making of bakery products. The processing of sweet potato into the flour product was one of the alternatives to increase the variety of products from the sweet potato-based. Also, it could encourage the farmers to run the sweet potato farm.

### 2.2.2 Composition of orange-fleshed sweet potato

Analysis	Fresh sample	Flour
Moisture content	69.42g / 100 g	10.97g / 100g
Ash	2.04g / 100 g	2.11g / 100g
Protein	3.69g / 100 g	4.80g / 100g
Fats	0.42g / 100g	0.39g / 100g
Starch	65.41g / 100g	33.66g / 100g
Crude fiber	3.68g / 100g	2.57g / 100g
Total carbohydrate	90.17g / 100g	90.13g / 100g

Table 2.1 – The composition of sweet potato based on literature  
(Rodrigues, Barbosa, & Barbosa, 2016)

From above Table 2.1, the orange-fleshed sweet potato has a good nutritional value which can make it a very good supplement food for the Malaysians. An orange-fleshed sweet potato is rich in total carbohydrate which is the main source of energy for our body. Besides, the orange-fleshed sweet potato also consists of  $\beta$ -carotene. The  $\beta$ -carotene is a red or orange pigment found in many fresh fruits and vegetables. The human body converts the  $\beta$ -carotene into a Vitamin A. Vitamin A is good for human health in maintaining healthy skin and mucus membranes, immune system and to have a healthy eye and vision.

### 2.2.3 Sweet potato peel flour production

As using a sweet potato peel as a functional ingredient in the making of waffle cones, firstly it needs to prepare the sweet potato peel flour. There are many methods to prepare the flour and it is easy to be done. According to Izalin et al. (2014), the sweet potato tubers were washed with clean water to remove dirt on the surface. Then it cut into slices. The slices then were dipped in the sodium metabisulphite solution to stop the enzymatic browning and to maintain the colour of the flour. After that, the slices were placed on the tray and were dried in the oven to remove the moisture in the sweet potato before it being ground. After the sweet potatoes were completely dried, it has been ground and it was sieved to get affine sweet potato flour. After the process was completed, the flour was packed properly and store at room temperature.

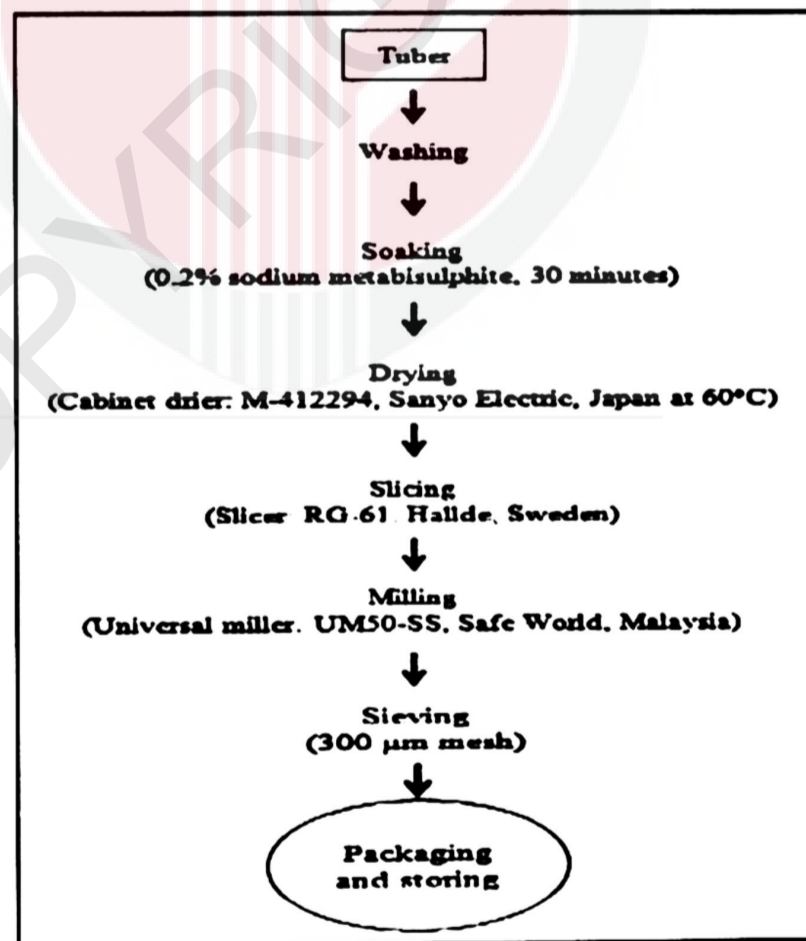


Figure 2.2 – Flowchart for the production of sweet potato flour by

(Mohd Hanim et al., 2014)

## **2.3 Overview of Waffle Cones**

### **2.3.1 Background and history of Waffle Cones**

An ice cream cone is a dry, cone-shaped pastry that has a similar texture to the waffle. It enables the ice cream to be held in the hand and eaten without a bowl or spoon. The first ice cream cone was produced in 1896 by Italo Marchiony. Marchiony, who was emigrated from Italy in the late 1800s, invented the ice cream cone in New York City. He was granted a patent in December 1903.

Although Marchiony is credited with the invention of the cone, a similar creation also was independently introduced in 1904 by St. Louis World's Fair by Ernest A. Hamwi was selling a waffle-like pastry in a booth next to the ice cream vendor. Ice cream becomes a sweet dessert that can be consumed by all people at all levels of ages, therefore at that time, the ice cream vendor ran out of dishes. Hamwi saw a solution to help the vendor. He quickly rolled one of his waffle-like pastries into the shape of a cone and gave it to the ice cream vendor. The cone was cooled in a few seconds, then the vendor put ice cream in the rolled waffle cone. The customers were very happy and the waffle cone has become the great American institution that it is today.

St. Louis, a foundry town that was capitalized on the cone's success. It enterprising the people to invent a piece of new special baking equipment for the making of waffle cone during the World's Fair cornucopia cones.

Stephen Sullivan of Sullivan, Missouri, was one of the first known independent operators in the ice cream cone business. In 1906, Sullivan served ice cream with the cone at the Modern Woodmen of America Frisco Log Rolling in Sullivan, Missouri. Same as Hamwi, he also was busy with the Cornucopia Waffle Company. In 1910, he founded the Missouri Cone Company, later known as Western Cone Company.

A modern ice cream cone was developed because of the demand from the people, there are two different types of cones were emerged. The first one was the waffle rolled into a cone-shaped. The waffle was baked in the round shape and rolled it as soon as it came out from the griddle. At an early stage, the waffle is rolled by hand, then it being rolled mechanically. In a few seconds, the rolled waffle was hardened in the form of a crisp cone.

The second type of cone was molded either by pouring the batter into a shell by inserting a core on which the cone was baked. After that, remove the core. The second option was by pouring the batter into a mold, baking it and then splitting the mold so that the cone could be removed with little difficulty.

In the 1920s, the waffle cone business has expanded. The cone production reached a record 245 million production number of the cone in 1924. Now, the millions of rolled cones are turned out by machines that are capable of producing about 150,000 cones in one day.

### 2.3.2 Texture analysis

The texture analysis is carried out to determine the quality of the waffle cones by the instrumental method by using the texture analyzer. The mechanical hardness, crispness, and the bending strength of the ice cream cone can be determined by the experimental description.

<b>Properties</b>	<b>Description</b>
Mechanical Hardness	The force required to break the cone.
Crispness	Micro-fractures occur until the waffle can no longer be crushed.
Bending Strength	Test done using three-point loading.

Table 2.2 – Properties measured using a texture analyzer

### 2.3.3 Sensory analysis

To introduce the desired texture and taste of the sweet potato peel waffle cones, the preparation of batter can be done by sensory analysis or sensory evaluation test. The difference in ingredient formula offers a different function to the waffle cones.

The implied that instrumental techniques for the mechanical hardness and crispness can be used to adequately judge the texture quality of the cones. The overall acceptability score for the ice cream has been done correlation between the two different parameters which are the mechanical hardness and the crispness. From the observation, the correlation was greater for the crispness. However, from the regression analysis, the

overall acceptability of the ice cream cone is due to the combined effect of crispness and the hardness.

## **2.4 Overview of Sweet Potato Peel Flour**

### **2.4.1 Advantage of sweet potato peel in health**

All know that sweet potato is high in nutritional values which is good for human health. Not only the sweet potato tuber is good, but the sweet potato peel also is safe to eat both, either raw or cooked. Sweet potato peel is rich in fiber, antioxidants and nutrients such as potassium, manganese, vitamin A and C where there are very useful and may help in improving the health of the body. Before the sweet potato peel can be eaten, it is important to properly clean the outer peel surface to remove the dirt and the other residue.

The sweet potato is a good source of fiber. However, their fiber content is reduced when the peel is removed. Therefore, the sweet potato peel also important in providing nutrients to the body. The fiber helps in increasing the feeling of fullness to the people. Therefore, people can reduce the portion amount of meals they eat. Besides, fiber also helps to manage the blood sugar and cholesterol levels in the body. Those beneficial function of fiber content are very beneficial to diabetes patients. High fiber also promote a healthy digestive system.

Besides, eating sweet potato peel also can increase the antioxidant intake in the human body. This is because the antioxidants tend to be concentrated in the peel and just below it, therefore eating sweet potato peel can increase the antioxidant intake in the body. Antioxidants are compounds that help defend the body against damage by free radicals.

Studies have suggested that the antioxidants in the sweet potato peel may help reduce the oxidation process, thereby reducing the risk of cancer.

#### **2.4.2 Proximate analysis**

Proximate analysis is the most important parameters that contributed to the quality of sweet potato peel flour as the special ingredient in the batter formulation for the making of waffle cone. The fiber, crude protein, fat, ash, carbohydrate and moisture content of the sweet potato peel flour were determined according to the Official Method of Analysis of Association of Official Analytical Chemist (AOAC) method.

For protein determination using the AOAC method, it was done by Kjeldahl method analysis. In the fat analysis, the fat content in the flour was determined by the Soxhlet extraction method by using the Soxtec extraction machine. The fat content in the food referred to the triglycerides, phospholipids, was ester, sterols and a minor amount of non-fatty materials. Next is the determination of ash content in the flour. Ash content was determined to measure the number of minerals present inside the food. Furthermore, the ash also an inorganic residue remaining after the water and the organic matter has been removed by the heating process. The fiber content has also been determining as it is one of the nutritious values in the sweet potato peel. Same as moisture content, it was determined according to the AOAC method and lastly, the carbohydrate obtained as the residue values of others nutrition values.

Besides the sweet potato peel flour, the nutritional content has also been determining for the waffle cone. The different values obtained in the nutritional content may be occurred due to the addition of sweet potato peel flour in the batter formulation of the waffle cone since it has different content than wheat flour. The difference in moisture and ash contents also due to the materials used in the study. In the waffle cone production, the ash act as an important quality measurement since it is related to the concentration of minerals in the samples. The moisture content of the sweet potato peel flour very important to be controlled because it could affect the packaging and the shelf life of the waffle cones.

## **2.5 Application of sweet potato peel flour**

Sweet potato peel flour was the flour with consists of high water and oil holding capacity (WHC and OHC). The sweet potato peel flour resulted in 295.94% of water holding capacity (WHC). The range of WHC from 149.1 to 471.5% is considered favorable for the preparation of viscous foods such as soups, gravies and bakery products (Anon, 1990). As the WHC value of this sweet potato peel in that range, thus it more suitable for making viscous foods rather than dried products such as this waffle cones. Because of that, the result for increasing the sweet potato peel flour (SPPF) amount in the batter leading to a decreasing of crispiness of the waffle cones.

Due to having high water and oil holding capacity, this sweet potato peel flour (SPPF) can be used for another application in food. As mention above, high WHC can be used in the preparation of viscous food products. Therefore, this sweet potato peel flour

can be used as the thickener in soups. Besides, this sweet potato peel flour also suitable for making bakery products such as cake or chewy cookies.

Besides, sweet potato peel flour (SPPF) also high in oil holding capacity (OHC). The OHC plays a role in ground meat formulations like sausages and also increases the shelf life of meat products (Akinyede & Amoo, 2009). Thus this sweet potato peel flour (SPPF) can be used to replace or substitute the maize flour or wheat flour in the making of food products on the meat-based products.

As mention above, sweet potato peel flour (SPPF) more suitable for making meat-based products due to its high water and oil holding capacity. This is proven where the sweet potato peel flour being used in the making of a hamburger (Marconato et al., 2020). Besides, the orange peel powder has also been used as the making of a beef burger (Mahmoud et al., 2017).

## **CHAPTER 3**

### **MATERIALS AND METHODOLOGY**

#### **3.1 Materials**

The main ingredient to make the sweet potato peel flour is the orange-fleshed sweet potato peel from the stall. The peel of the sweet potato comes from my final year project mates which are used the flesh of the orange-fleshed sweet potato in the making of flour. To reduce the number of waste of the sweet potato waste, it is collected and undergoes a process of producing flour. The peels are being soaked in the water solution to prevent enzymatic browning occurs and to enhance the colour of the flour later.

For the batter ingredient for the making of waffle cone, the ingredients include the wheat flour, sweet potato peel flour, white sugar, salt, egg, butter, evaporated milk and vanilla essence. The wheat flour and the sweet potato peel flour are substituted into the batter ingredients according to it different ratio formulation.

### 3.2 Preparation of Sweet Potato Peel Flour

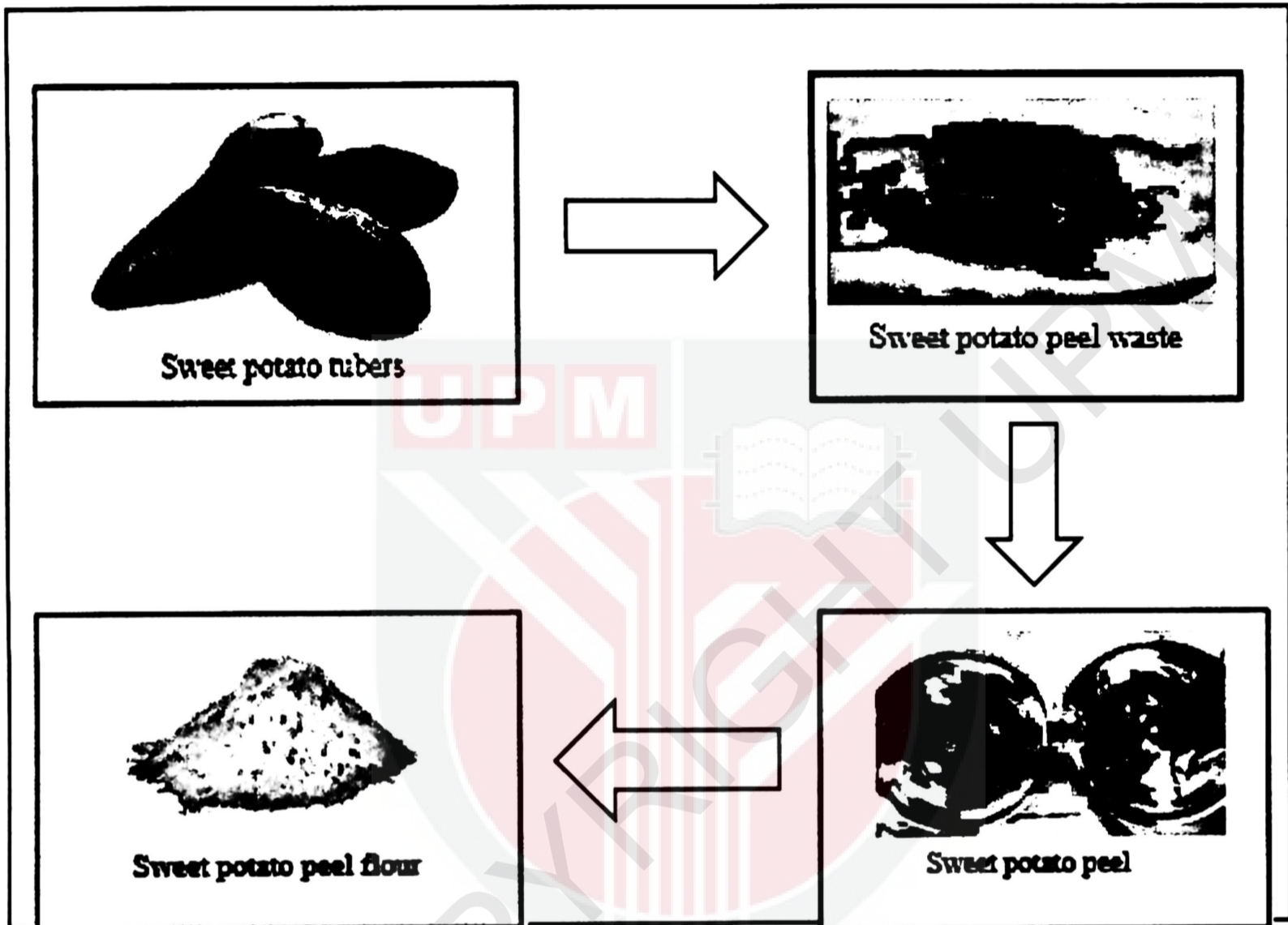


Figure 3.1 – Step of production of sweet potato peel flour (SPPF)

First, the sweet potato peel was removed from its tubers. The waste of sweet potato peel was received from the fried sweet potato stall at Taman Sri Serdang. The sweet potato peels were cleaned using the tap water to remove all the dirt and the latex from the surface of the tubers. The washing step is the most critical in the production of sweet potato flour because it enhanced the quality of the end-product of flour depends on how the washing has been conducted (Hagenimana & Owori, 2004).

After completing the washing, the sweet potato peels were dried in the oven at 65° C for 7 hours until the moisture content reaches below 5%. The moisture content must be at a low level to ensure the flour is safe for storage. After the sweet potato peels were completely dried, it is ground using the multi-grinder to obtain the flour structure of sweet potato peel flour. Then, the ground sweet potato peel flour was sieved using a siever machine at 125 µm size to have a fine structure of flour. After all the production step has been completed, the flour is pack in the zip bag to prevent it from exposure to the surrounding moisture which could affect the quality of the flour. The packed flour were store at room temperature before undergoing further analysis.

### 3.3 Preparation of Batter

Formulations used for the waffle cones batter are shown in Table 3.1. There are four different formulations used in the making of waffle cones batter. For the control formulation, it uses 100% of wheat flour in the batters formulation. The other three batter of waffle cone samples were prepared by substituting wheat flour with 5%, 10% and 15% of sweet potato peel flour. Besides flour, there are extra ingredients such as sugar, egg, salt, butter, evaporated milk and vanilla essence were included in the batter formulation of waffle cones making.

Formulation of waffle cones batter	Ratio (Wheat flour : Sweet potato skin flour)
Control	100:0
5 % SPSF	95:5
10% SPSF	90:10
15% SPSF	85:15

Table 3.1 – Ratio of flour

Ingredient	Formulation of batter			
	Control	5% SPSF	10% SPSF	15% SPSF
Wheat Flour(g)	100	95	90	85
Sweet Potato Skin Flour (g)	0	5	10	15
Sugar (g)	70	70	70	70
Egg	2	2	2	2
Salt (g)	2	2	2	2
Milk (ml)	90	90	90	90
Essence Vanilla (ml)	3	3	3	3

Table 3.2 – The batter formulation of making waffle cones

First, all the ingredients are measured according to the desired formula in Table 3.2 and being mix together. Firstly the flour and the salt are mixed in the first container while the sugar and eggs are mixed in the second container. Secondly, the mixture of flour and salt are poured into a mixture of sugar and eggs container and mixed it well. Thirdly, the evaporated milk and butter are added to the mixed ingredients. The mixture stirred continuously until it was well mixed. After all the ingredients are well mixed, the batter is cook on the waffle pan maker at 150 ° C for 3.5 minutes. After it is fully cooked, take out the waffle from the pan and rolled it into a cone shape.

### **3.4 Sweet Potato Peel Flour Analysis**

The sweet potato peel flour was characterized for their proximate composition such as fiber, crude protein, fat, ash, carbohydrate and moisture content. An additional component that can be analyzed from the sweet potato peel flour are  $\beta$ -carotene and polyphenol content is the sweet potato peel.

#### **3.4.1 Proximate analysis**

##### **3.4.1.1 Protein Analysis**

The sample used is sweet potato peel flour. The dry sample was weighed about 0.15g using the Micro Kjeldahl method. The sample was placed in the micro Kjeldahl test tube. For the blank, there was no sample used. Then, 0.8g of mixed catalyst (96% sodium sulphate anhydrous + 3.5% cuprum sulphate + 0.5% selenium dioxide) was added into the test tube. Using a pipette, added 2.5 ml of concentrated sulphuric acid into the test tube and swirl the tube gently to ensure the content all fully mixed. After that, heat the test tube slowly on the heating coil under the fume hood. Boil the content until the solution becomes clear and gives the blue-green colour. After the colour being obtained, cool the flask until 40 ° C.

Added 10 ml of distilled water into the distillation tube and also transfer the digested product into the distillation tube. After that, 10ml of 45% NaOH solution was slowly added into the tube to separate the two layers of the solution. Then, fixed the distillation tube to the condenser neatly.

In the other conical flask, 10 ml of 2% boric acid and a few drops of the indicator were being added to give the solution a green colour. The conical flask is placed at the distillate platform and being immersed in the tip of the distillation tube into the acid solution. The content of the distillation flask being mixed by swirl it gently. Purge steam into the flask. Then, the ammonia solution being distilled into the conical flask for about 120 ml. After the distillation product being mixed, it is titrated by unreacted boric acid with 0.05N H<sub>2</sub>SO<sub>4</sub> until the solution change into purple colour.

Calculation:

Weight of sample

= W

Volume of H<sub>2</sub>SO<sub>4</sub> to titrate boric acid

= I<sub>s</sub>

Volume of H<sub>2</sub>SO<sub>4</sub> to titrate blank

= I<sub>b</sub>

Normality of H<sub>2</sub>SO<sub>4</sub>

= N

% of Nitrogen

$$= \frac{(I_s - I_b) \times N \times 1.4}{W}$$

% of Protein

= % Nitrogen x conversion factor

Used conversion factor 6.25 for others food.

### 3.4.1.2 Fat Analysis

First, the round bottom flask was placed into the oven at  $105^{\circ}\text{C}$  for about 30 minutes. The sample used in this experiment is sweet potato peel flour. 5g of the sample being weighed in the thimble. Then, the thimble has been inserted into the Soxhlet apparatus. Weighed the dried round bottom flask, then 200ml of petroleum ether being poured into the flask. After that, the Soxhlet was connected to the reflux and round bottom flask. Then, refluxed the sample continuously for about 8 hours. The water content in the water bath must be sufficient and need to be added if necessary and the temperature of the heater also needs to be controlled. Need to be extra cautious by making sure that the solvent is not evaporated or dry during the refluxing process. If so, petroleum ether needs to be added.

After 8 hours, the petroleum ether evaporated from the round bottom flask using the evaporator. After that, placed the round bottom flask in the oven at  $105^{\circ}\text{C}$  for about 15 minutes. Then, the round bottom flask cooled in the desiccator. The round bottom flask weighed together with the fat extracted.

Calculation:

Weight of sample (g)	= W
Weight of round bottom flask (g)	= Result from experiment
Weight of round bottom flask + oil (g)	= Result from experiment
Weight of oil (g)	= M

$$\% \text{ of oil sample} = \frac{M}{W} \times 100$$

### 3.4.1.3 Ash Analysis

The total ash content of the samples are determined based on the vaporization of water and volatiles with burning organic substances in the presence of oxygen in the air to the carbon dioxide at 550 ° C by using a furnace. Placed the crucible in the oven at 105° C for 1 hour. Then, cooled the crucible in the desiccator. After the crucible cool, weighed the crucible rapidly. After that, weighed 3-5g of the sample in the crucible. Then, insert the crucible with the sample into the muffle furnace at 550 ° C. The sample needs to be burned at least for 2 hours or until no black particle present to obtain the permanent weight. Cooled the crucible and ash in the desiccator and weighed the crucible together with the ash.

Calculation:

$$\% \text{ of Ash} = \frac{(\text{Weight of ash+Weight of crucible})-(\text{Weight of crucible})}{(\text{Weight of sample})} \times 100$$

### 3.4.1.4 Crude Fiber

First, the crucible and the ashless filter paper being dried in the oven at 105 ° C for 1 hour. Then both crucible and the ashless filter paper were cooled in the desiccator. After it is cool, the filter paper being weighed. About 2 g of the defatted sample being weighed and placed into a 500 ml conical flask. After that, 200 ml of boiling sulphuric acid was added and being dissolved using the spatula. Then, the conical flask is attached to the reflux condenser. At this stage, ensure the water was running in the condenser.

The sample was boiled for 30 minutes. The conical flask was turned for every 5 minutes to make sure that the sample always in contact with the acid. After that, the hydrolyzed mixture was filtered through the filter paper Whatman No.541. The residue was rinsed with the boiled distilled water to remove the acid from the filtrate. Then, place back the residue into its conical flask and 200 ml of boiled sodium hydroxide was added into the conical flask. Then, attached the conical flask to the condenser and boiled for another 30 minutes. The hydrolyzed mixture that has been boiled through dried being filtered and the filter paper was being weighed. Rinsed the residue with the boiled distilled water until the filtrate is free from alkaline. Rinse again with a small amount of alcohol and then drain it.

Next, place the residue and the filter paper into the crucible and dry in the oven at  $105^{\circ}\text{C}$  for 1 day. Then the weight of the crucible and the filter paper being weighed. After that, place the crucible in the muffle furnace at  $550^{\circ}\text{C}$  and then burn it completely. After it is completely burned, place the crucible into the desiccator to be cooled and the constant weight was calculated.

Calculation:

Weight of sample = W

Weight of filter paper without ash = K

Weight of crucible + filter paper + dried residue = S

Weight of crucible + ash = A

$$\% \text{ of Crude fiber} = \frac{(S-K)-A}{W} \times 100$$

#### **3.4.1.5 Moisture Content**

The determination of moisture content in the sample by using the moisture analyzer (AND MX-50). 2 g of sample were placed on the tray inside the moisture analyzer. The sample was heated at 105 ° C for a certain time until all the moisture in the flour sample was reduced. The result showed the percent (%) of moisture content.

#### **3.4.1.6 Carbohydrate Analysis**

The method used in determining the total percentage of the carbohydrate content in the sample involving the subtraction of 100% to the sum of the total value of moisture content, crude protein, fat, ash and crude fiber constituents of the sample. The determination of carbohydrate was calculated as below.

$$\% \text{ Carbohydrate} = 100\% - ( \% \text{moisture} + \% \text{protein} + \% \text{fat} + \% \text{ash} )$$

### **3.4.2 Water and Oil Holding Capacity**

Water holding capacity (WHC) is defined as the ability of a protein matrix to absorb and retain bound, hydrodynamic, capillary and physically entrapped water against gravity (Traynham et al, 2007).

#### **3.4.2.1 Water Holding Capacity (WHC)**

The WHC was determined using methods modified from Beuchat (1977) and (Hussain & Choudhry, 2014). The sample used in this experiment was the sweet potato peel flour (SPPF). The sweet potato peel flour weighed about 1g. The 1g was vortexed with 10 ml of distilled water in a pre-weighed centrifuge tube for 30 minutes. After standing at room temperature for 30 minutes, the sweet potato peel flour was centrifuged for 25 min at 3000 xg. The sediments were weighed after the complete removal of the supernatant.

Calculation:

$$\text{WHC (\%)} = [(W_2 - W_1) / W_0] \times 100$$

$W_0$  = weight of the sample

$W_1$  = weight of centrifuge tube + sample

$W_2$  = weight of centrifuge tube + sediments

### 3.4.2.2 Oil Holding Capacity (OHC)

For the determination of oil holding capacity (OHC), the sweet potato peel flour weighed about 0.5g was homogenized with 5ml canola oil in a pre-weighed centrifuge tube for 30 minutes. After standing the sample at room temperature for 30 minutes, the sample was centrifuged for 25 minutes at 3000 xg. The sediments were weighed after the complete removal of the supernatant.

Calculation:

$$\text{OHC (\%)} = [(W_2 - W_1) / W_0] \times 100$$

$W_0$  = weight of the sample

$W_1$  = weight of centrifuge tube + sample

$W_2$  = weight of centrifuge tube + sediments

### **3.5 Waffle Cones Analysis**

The different batter formulation used affects the properties of the waffle cone including to its texture, colour, aroma and also the acceptability of the sweet potato peel waffle cone by people. Analysis has been done to determine the texture properties of the waffle cone to determine which characteristics of the waffle cone that could meet the local people acceptability.

#### **3.5.1 Texture Analysis**

The texture analysis of the waffle cone has been done using the texture analyzer equipment. The texture analyzer testing was done by using a 2 mm cylindrical probe. The determination that can be made from the texture analyzer was the waffle cone hardness, brittleness, toughness and crispness. The analysis also was carried out a triplicate sample at room temperature. This test was on the flat waffle and a cone-shaped waffle. For the first run, the test is done on the flat waffle since the end tip of the probe used is flat and therefore, the probe can penetrate evenly into the waffle during the test and errors can be minimized.

The second run of the texture analyzer is then done using a sample of a cone-shaped waffle. This sample also run triplicate. The probe for texture cone shape waffle is using the ice cream cone rig with a triggered force that automatically set-up by the machine.

### **3.5.2 Moisture content of waffle cones**

The moisture content is one of the important parts that need to be considered in the production of food products. The moisture content of the food products determines the shelf life of the products. The presence of moisture in the products could enhance the growth of microorganisms which can shorten the shelf life of the products. In the making of a good and crispy structure of waffle cones, the moisture content must be below 2%. Increasing moisture content of the waffle cones shows the waffle cones texture becomes less crispy. The moisture content of the waffle cones measured using the moisture analyzer (AND MX-50).

### **3.5.3 L\*a\*b\* colour analysis**

L\*a\*b\* colour analysis was done to determine the change of colour on the texture of the waffle cones by adding the sweet potato peel flour in the batter formulation. The colour is measured on the surface of the waffle cones using the colorimeter. L\* is for the lightness from black ( 0 ) to white ( 100 ), a\* from green ( - ) to red ( + ), and b\* from blue ( - ) to yellow ( + ).

### **3.5.4 Sensory Analysis**

The sensory analysis can be done after the sweet potato peel flour was added into the formulation of the batter, control, 5% SPPF, 10% SPPF and 15% SPPF and it baked into a waffle cone at 200<sup>o</sup> C for 1.5 minutes. Then, the analysis is done to 20 untrained test panels that involved the local people from the Faculty of Engineering, University Putra Malaysia (UPM) and also from people in my hometown. This analysis is done to

**determine the colour, aroma, taste and texture of the waffle cone for their acceptability.**

**There are 4 samples are given to each panel for evaluation. The 4 samples are chosen from the same baking parameters but the different composition of sweet potato peel flour in the batter formulation.**



## CHAPTER 4

### RESULTS AND DISCUSSION

#### 4.1 Proximate analysis of sweet potato peel flour

Proximate analysis is a method to determine the value of macronutrients in the food samples. In this study, the sample of food used is the sweet potato peel flour where the sweet potato peel was being processed into flour to be used in the application of food. A combination of different techniques such as an extraction, Kjeldahl, NIR is used to determine the moisture, protein, fat, fiber, ash and carbohydrate content in the food sample.

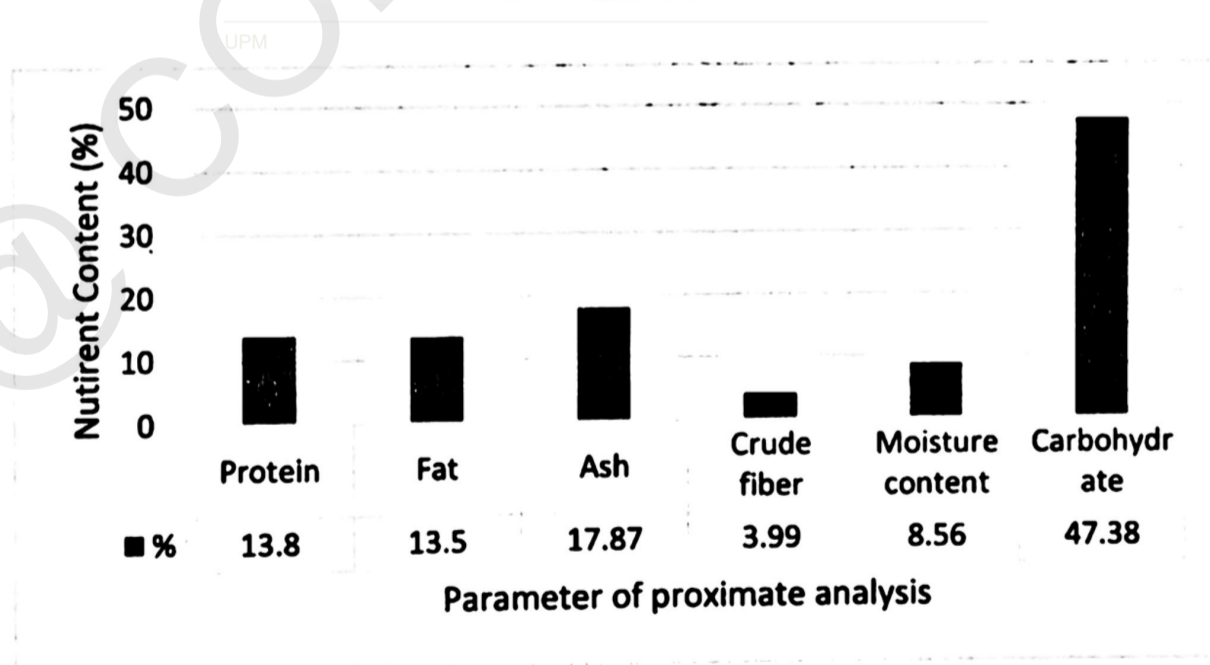


Figure 4.1 – Proximate analysis of sweet potato peel flour (SPPF)

<b>Parameter</b>	<b>Orange-fleshed Sweet potato peel flour (%)</b>	<b>Purple-fleshed Sweet potato peel flour (%) (Marconato et al., 2020)</b>	<b>Banana peel flour (%) (Zaleqha, 2019)</b>
<b>Protein</b>	13.8	5.53	6.5
<b>Fat</b>	13.5	1.03	13.0
<b>Ash</b>	17.87	5.26	7.0
<b>Crude fiber</b>	3.99	12.76	16.6
<b>Moisture content</b>	8.56	4.32	8.9
<b>Carbohydrate</b>	47.38	71.09	71.0

**Table 4.1 – Comparison of three different flour**

#### 4.1.1 Protein content

Protein is one of the important components for every cell in the body where the protein is a “macronutrient” where the body relatively needs a large amount of it. The body uses the protein to build and repair tissues. Besides, it also important in the building block of bones, cartilage, muscle, blood and also skin. Besides, protein also beneficial for unhealthy people as it

<b>Peel flour</b>	<b>Protein content (%)</b>
Orange-fleshed sweet potato peel flour	13.8
Purple-fleshed sweet potato peel flour	5.53
Banana peel flour	6.5

Table 4.2 – Percentage composition of protein content

Table 4.2 above shows the result of the protein content in three different types of flour. From the result, the orange-fleshed sweet potato peel has higher protein content compared to the purple-fleshed sweet potato peel flour and banana peel flour. The high protein content beneficial especially for healthy lifestyle people in helping to prevent colon cancer, treating diabetes and also help in controlling the weight of the body. Thus, this sweet potato peel flour can be an added of the nutritional value of protein for the human body.

#### 4.1.2 Fat analysis

<b>Peel flour</b>	<b>Fat content (%)</b>
Orange-fleshed sweet potato peel flour	13.5
Purple-fleshed sweet potato peel flour	1.03
Banana peel flour	13.0

Table 4.3 – Percentage composition of fat content

Table 4.3 shows the fat content in the sweet potato peel flour (SPPF) was 13.5% which is higher compared to the other peel flour. However, the sweet potato peel flour and banana peel flour have the same fat content, but for the purple-fleshed peel flour, the fat content much lower than the other two types of peel flour. Besides, the fat content of this sweet potato peel flour (SPPF) also high compared to the fat content of the fresh sweet potato peel with fat content only 0.83% (Dusuki, et. al., 2020). The other research found that the fat content of sweet potato peel was only 4.71% which also lower than the result obtained for the sweet potato peel flour (SPPF) sample (Gabriel, et. al., 2015).

The higher fat content in the sweet potato peel flour (SPPF) due to the higher oil holding capacity (OHC). The more oil retained in the flour, the higher the fat content in the flour. The intake of food with higher fat content needs to be reduced because it is not good for health.

### 4.1.3 Ash analysis

Ash composition is important in determining mineral content (Nollet, 2004). The mineral contents found in the food consists of zinc, potassium, sodium, calcium, iron and magnesium which healthy for human health. Generally, natural food has and ash content of less than 5% while some processed food can have ash content more than 10%.

<b>Peel flour</b>	<b>Ash content (%)</b>
Orange-fleshed sweet potato peel flour	17.87
Purple-fleshed sweet potato peel flour	5.26
Banana peel flour	7.0

Table 4.4 – Percentage composition of ash analysis

Table 4.4 above shows the result for the ash content in the three different flour. The result of the ash content of the sweet potato peel flour is 17.87% as it is a dried food sample. Research also has been done on the proximate composition of tubers peel which gave a result of 14.18% of ash content of the orange-fleshed sweet potato peel (Dusuki et al., 2020). The high ash levels indicate that there has been material contamination happened by the tool due to friction during the processing or there must be contamination of flour with the bran. The high ash content not good for health therefore needs to reduce the intake in this food which high content of ash. Reducing the number of minerals in the diet can help to minimize the growth and urinary tract problems in the body (Cindy, 2018).

#### 4.1.4 Crude fiber content

<b>Peel flour</b>	<b>Crude fiber content (%)</b>
Orange-fleshed sweet potato peel flour	3.99
Purple-fleshed sweet potato peel flour	12.76
Banana peel flour	16.6

Table 4.5 – Percentage composition of the crude fiber content

From (Vaitkevičienė, 2019), it stated that a peel was higher in fiber content, but the result obtained in Table 4.5 not the same as the previous result. From this observation, the crude fiber content in the sweet potato peel flour only 3.99%. This result shows that the orange-fleshed sweet potato peel flour (SPPF) has lower crude fiber content compared to the purple-fleshed sweet potato peel flour and the banana peel flour. The research on the sweet potato peel by (Gabriel et al., 2015) also shows that the crude fiber content of the sweet potato peel was 3.56%.

The crude fiber useful in the chemical determination of succulence of fresh vegetables and fruits and also the over mature products have increased the level of crude fiber. The crude fiber consists large of cellulose and lignin. This fiber content is beneficial to treat and prevent constipation, hemorrhoids, diverticulosis, coronary heart disease and also some type of cancer (Madhu, Krishna, Reddy, Lakshmi, & Kelari, 2017).

#### 4.1.5 Moisture content

The determination of moisture content of the sweet potato peel flour has been done using the moisture analyzer (AND MX-50). The determination using the moisture analyzer more accurate compared to the manual experiment. This moisture content is important to maintain the shelf life of the sweet potato peel flour.

<b>Peel flour</b>	<b>Moisture content (%)</b>
Orange-fleshed sweet potato peel flour	8.56
Purple-fleshed sweet potato peel flour	4.32
Banana peel flour	8.9

Table 4.6 – Percentage composition of moisture content

The moisture content for this sweet potato peel flour was 8.56%. This result a little bit high from the previous research where the moisture content of flour must below 5% to prevent the growth of microorganisms on the sweet potato flour (Mohd Hanim et al., 2014). The other research showed that the moisture content of the flour must between 6-7% (Ahmed, Akter, & Eun, 2010). Besides, research was also done on the purple-fleshed sweet potato peel flour (SPPF) where it resulted in the moisture content of 4.32% (Marconato et al., 2020). This result showed the moisture content of purple-fleshed sweet potato peel flour lower than the moisture content of the orange-fleshed sweet potato peel flour. This high value of moisture content can enhance the growth of the microorganisms. Also, the storage of the flour influenced the moisture content of the flour. The flour has

been sealed properly and store in the tight container, but at the moment to run the experiment, the flour exposed to the surrounding humidity was increased the moisture content of the flour.

#### 4.1.6 Carbohydrate content

Carbohydrate = 100% - Moisture content (%) - Ash content (%) - Fat content (%) – Protein content (%)

$$= 100 - 8.65 - 17.87 - 12.30 - 13.80$$

$$= 47.38 \%$$

Peel flour	Carbohydrate content (%)
Orange-fleshed sweet potato peel flour	47.38
Purple-fleshed sweet potato peel flour	71.09
Banana peel flour	71.0

Table 4.7 – Percentage composition of carbohydrate content

The fresh sweet potato peel also consists high in carbohydrate which could reach 78.3% on the previous research that has been done on the tubers peel (Dusuki et al., 2020). From the result of Table 4.7 above, the carbohydrate content in the sweet potato peel flour was 47.38%. The carbohydrate content in the sweet potato peel flour was reduced during the process of producing the sweet potato peel flour. During the production, the sweet potato peel needed to be dried before being ground into a fine form of flour. This may be

caused by the loss of carbohydrate content in the food sample. Although its carbohydrate content a little bit lower from the fresh sweet potato peel, the carbohydrate content still can be said as high where this carbohydrate very beneficial for the human body as the main source of energy for the body. In addition, the carbohydrate also helps to fuel the brain, kidneys, muscles and also the central nervous system.

Comparison between the orange-fleshed sweet potato peel flour, purple-fleshed sweet potato peel flour and the banana peel flour, the orange-fleshed peel flour shows the lowest carbohydrate content. This lower carbohydrate content is suitable for people who want a healthy lifestyle in reducing the carbohydrate intake. Therefore, this orange-fleshed sweet potato peel flour suitable for the people in the diet.

## 4.2 Analysis of water and oil holding capacity of sweet potato peel flour

Parameter	%
Water holding capacity	295.94
Oil holding capacity	329.97

Table 4.8 – Result of water and oil holding capacity of sweet potato peel flour

### 4.2.1 Water holding capacity

It is defined that water holding capacity (WHC) of foods as the ability of food to hold its own and added water which involved the application of forces, pressing, centrifugation or heating. Hermansson, A. M. (1986) defined the water holding capacity (WHC) as the physical property and the ability of a food structure to prevent water from being released from the three-dimensional structure of the protein. From this study, an observation has been done on the water holding capacity of the sweet potato peel flour and the result obtained was 295.94%. The high water holding capacity obtained showed that the sweet potato peel flour was high in hydrophilic nature and high hydrogen bonding of protein molecules.

From the previous research, the range of water holding capacity (WHC) from 149.1% to 471.5% was favorable for the preparation of viscous foods such as soups, gravies and the bakery products (Anon, 1990). The result of water holding capacity (WHC) of this sweet potato peel flour was in the range where it is suitable for the preparation of viscous food. Therefore, in the making of waffle ice cream cone from the

sweet potato peel flour in this study shown result on less of crispiness of waffle ice cream cone as the increases of amount of sweet potato flour added to the batter formulation of waffle ice cream cone making. This result of the crispiness of the waffle ice cream cone will be further discussed in the texture analysis of the waffle ice cream cone below.

Due to this higher water holding capacity (WHC), the sweet potato peel flour more suitable for application in the meat-based product. The sweet potato peel flour (SPPF) was successful as an ingredient in the bovine hamburger formulation such it gave a positive influence on some hamburger technological characteristics by increasing the moisture retention and reduction of fat retention in the making of hamburger (Marconato et al., 2020). This successful result of sweet potato peel flour in the making of meat-based products is also proven in the making beef burger (Mahmoud. et. al., 2017). Thus from those previously researched, is proven that the flour with high water holding capacity (WHC) more suitable in making viscous food products rather than dried food products such as these waffle cones. Therefore, this application of sweet potato peel flour (SPPF) can be more focusing on the viscous food products.

#### **4.2.2 Oil holding capacity**

Oil holding capacity is defined as the amount of oil that a sample can absorb per unit of weight. The oil holding capacity (OHC) measured by putting the sample in an excess of oil and the free oil will be eliminated by the centrifugation process. An ingredient with the high oil holding capacity (OHC) can be used to improve the product's texture. In this study, it resulted that sweet potato peel flour has a high value of oil holding capacity (OHC) which reached 329.97%. High oil holding capacity (OHC) enhanced the hydrophobic character of proteins in the flour. Oil holding capacity exhibited the proteins in the flour where it is physically bound to the fat by the capillary attraction. These proteins in the flour are more exposed to the non-polar amino acids compared to the fat which enhanced the hydrophobic behavior where the flour can absorb the oil. This high oil holding capacity of food is significant for the ground meat formulations like sausages and could increase the shelf life of the meat products (Akinyede & Amoo, 2009).

From the study that has been carried out, the sweet potato peel flour has been used in the making of waffle ice cream cone. As the oil holding capacity (OHC) found was high, this flour did not very suit for making of waffle ice cream cone which needs to be high in crispiness which needed to be fulfilled the customer demand. Therefore, this sweet potato peel flour was more suitable for making the meat-based food products.

### 4.3 Waffle cones analysis

Texture analysis has been done on the waffle ice cream cone in determining the strength of the waffle ice cream structure. The texture of the waffle ice cream needed to be observed to ensure the waffle ice cream cone produced later can meet the acceptability of the customers. Analysis of the texture of the waffle ice cream cone has been determined by using the TA.XT plus texture analyzer with the ice cream cone support rig. Using this apparatus, the cone strength is defined as the amount of force required to cause breakage when a ball-shaped object is pressed into the cone using compression platen while the cone is supported by the rig.

#### 4.3.1 Texture analysis of waffle cones

Test	Hardness (N)	Brittleness (mm)	Toughness (N.sec)	Crispiness (F)	Moisture Content (%)
Control	3.35 ± 0.88	3.51 ± 1.65	3.60 ± 0.62	21.67 ± 5.86	1.57 ± 0.13
5% SPPF	7.47 ± 2.20	3.57 ± 0.99	8.40 ± 5.55	20.33 ± 2.52	1.98 ± 0.33
10% SPPF	9.12 ± 6.62	3.92 ± 1.81	8.49 ± 9.60	13.00 ± 9.17	2.77 ± 0.25
15% SPPF	5.77 ± 2.57	3.75 ± 0.69	4.97 ± 1.54	15.67 ± 10.0	3.1 ± 0.42

SPPF = Sweet Potato Peel Flour

Table 4.9 – Tabulated data of texture analysis of waffle cones

Table 4.9 shows the results of the texture analysis of waffle ice cream cone measured using the instrumental methods as characterized by the hardness, brittleness, toughness and the crispiness for four different of waffle ice cream cone.

#### 4.3.1.1 Hardness

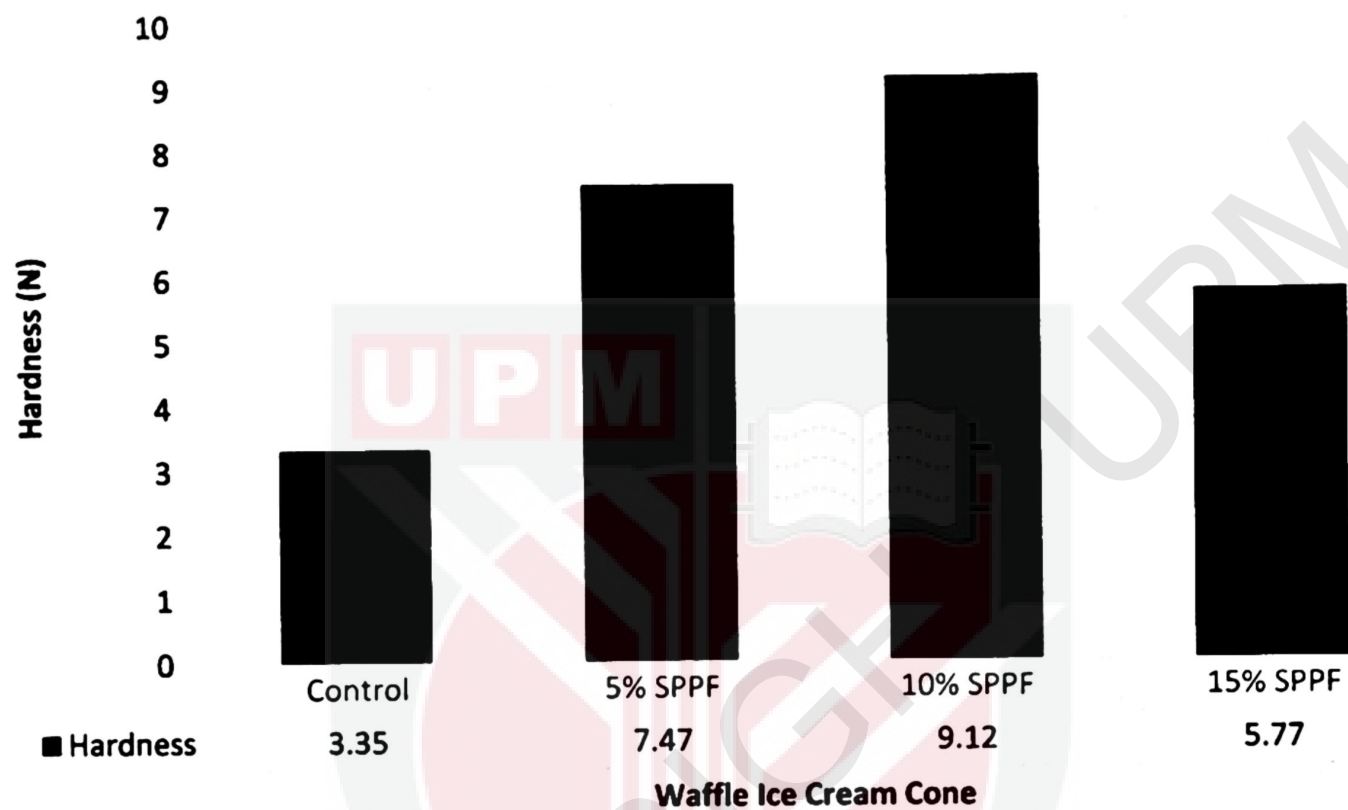


Figure 4.2 – The hardness of waffle cones

The results obtained from the texture analysis has been transferred into graph form for it to be seen as more clear and easy to be compared. Figure 4.2 shows the result for the hardness of waffle ice cream cones. From the result obtained, the substitution of 10% of sweet potato peel flour (SPPF) into the wheat flour in the batter formulation shows the highest in hardness value while the control sample where there was no addition of sweet potato peel flour in the batter formulation resulted in the lowest of the hardness of the waffle cones. Also reported from the previous research, the lipids affected the softness and the crispiness of the baked products (Hadiyanto et al., 2011). This is because of the

high water and oil holding capacity of the sweet potato peel flour (SPPF) which affects the texture of the waffle cones. The oil remains in the flour subsequently reducing the mechanical hardness of the waffle ice cream cones structure.

#### 4.3.1.2 Brittleness

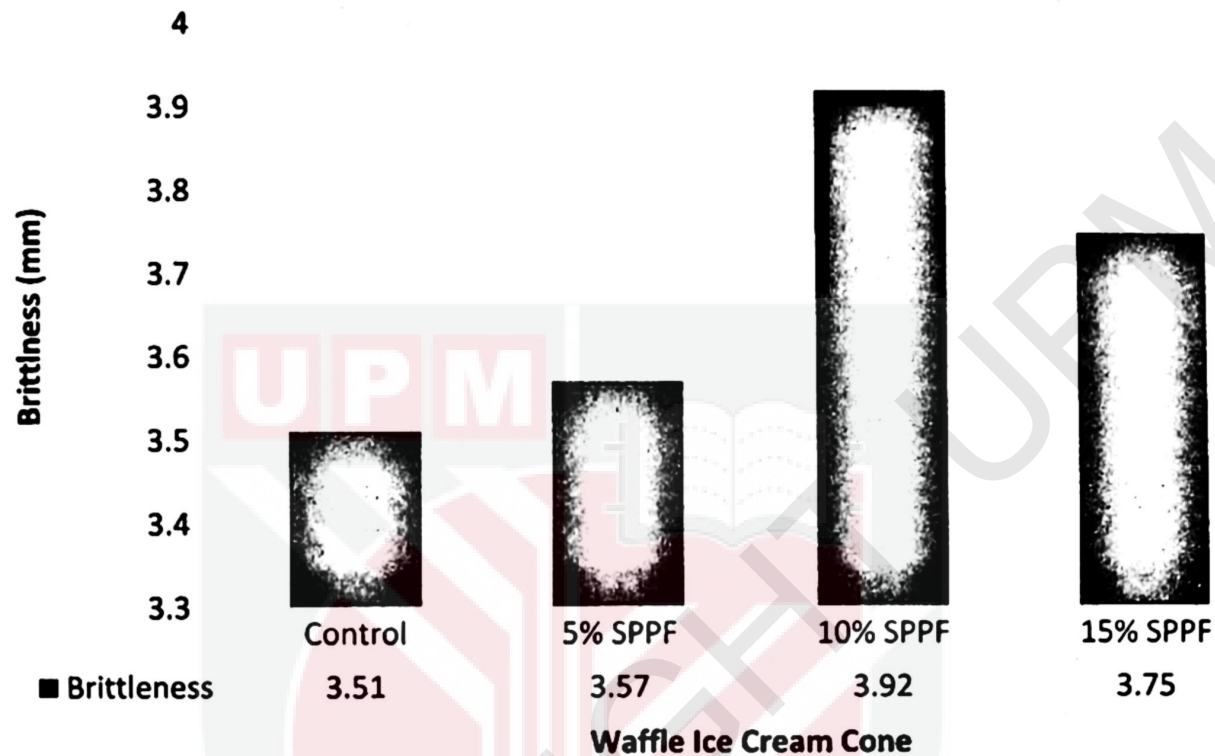


Figure 4.3 – The brittleness of waffle cones

Figure 4.3 above shows the brittleness of the texture waffle cones. Brittleness was the inclination condition of cones to crack or fail when a small force applied. From the result of the texture analysis, the 10% SPPF showed the highest brittleness while control waffle cones show the lowest brittleness of waffle ice cream cone. For the result of brittleness, a waffle ice cream cone from four different batter formulation gave a result within the same range. The result shows that addition of sweet potato peel flour (SPPF) in the batter formulation increases the brittleness of the waffle ice cream cones. The 10% SPPF with high brittleness value shows that the waffle cones need more force before it starts to crack. Besides, the strong texture help for the distribution of the product to the

market by ensuring the product is delivered to the customers in a good condition. If the waffle ice cream cone easily cracks, then the appearance of the waffle ice cream cone is received by the customer, not in a nice look.

### 4.3.1.3 Toughness

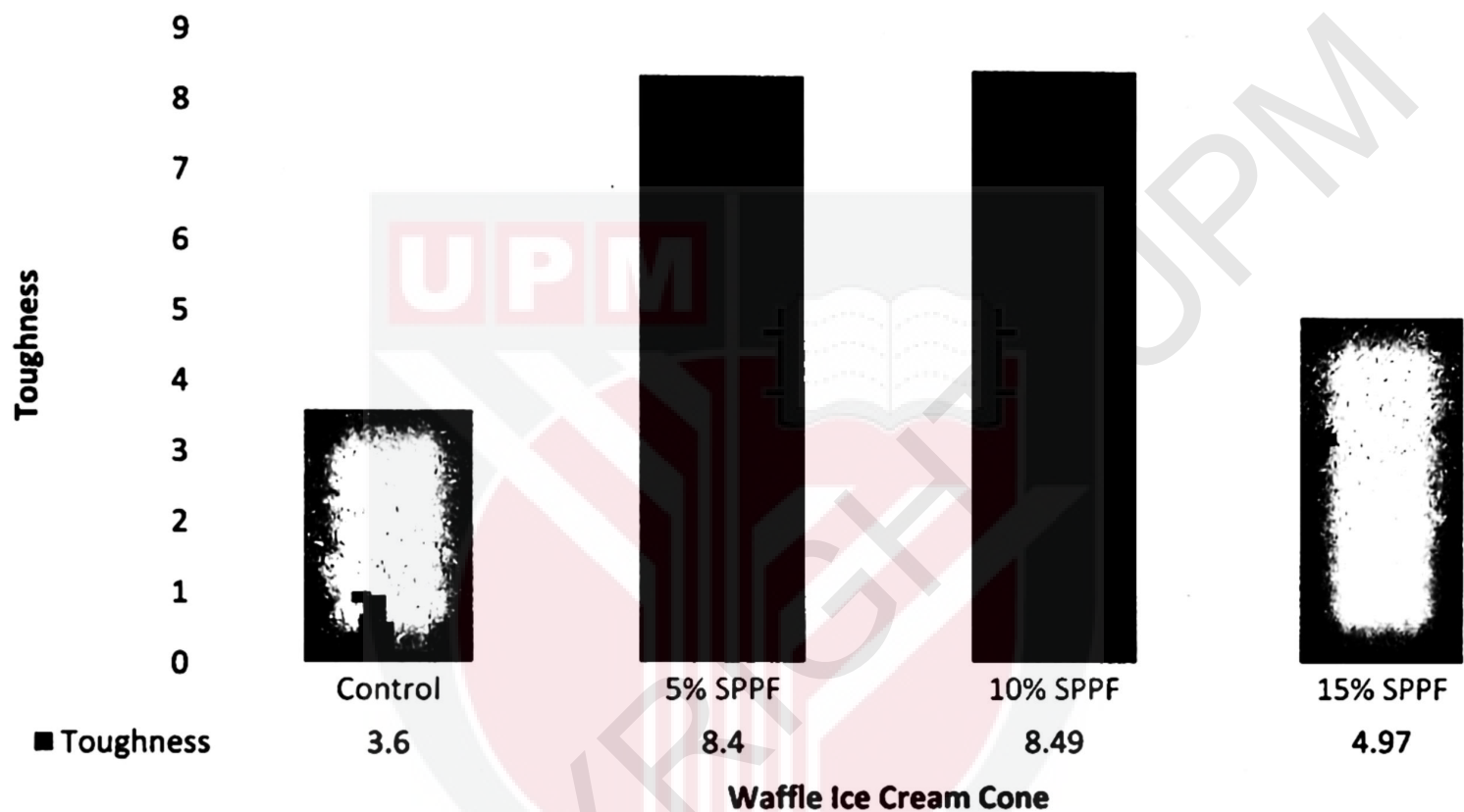


Figure 4.4 – The toughness of waffle cones

The next parameter measured on the texture of waffle cones was the toughness. The toughness of the waffle ice cream cones defined as the condition of a cone to resist breaking when force is applied. Results obtained from the analysis shown 10% SPPF gave the highest toughness of the waffle ice cream cone while the control sample of waffle ice cream cone where there was no addition of sweet potato peel flour (SPPF) resulted in the lowest toughness of the waffle ice cream structure. From Figure 4.2 and Figure 4.4, the addition of sweet potato peel flour (SPPF) affected the waffle ice cream cone texture by

increasing its hardness and toughness. Increasing the result of the toughness of the waffle ice cream cone texture eventually prevents the waffle ice cream cone from easily broken or crack during the handling process.

#### 4.3.1.4 Crispiness

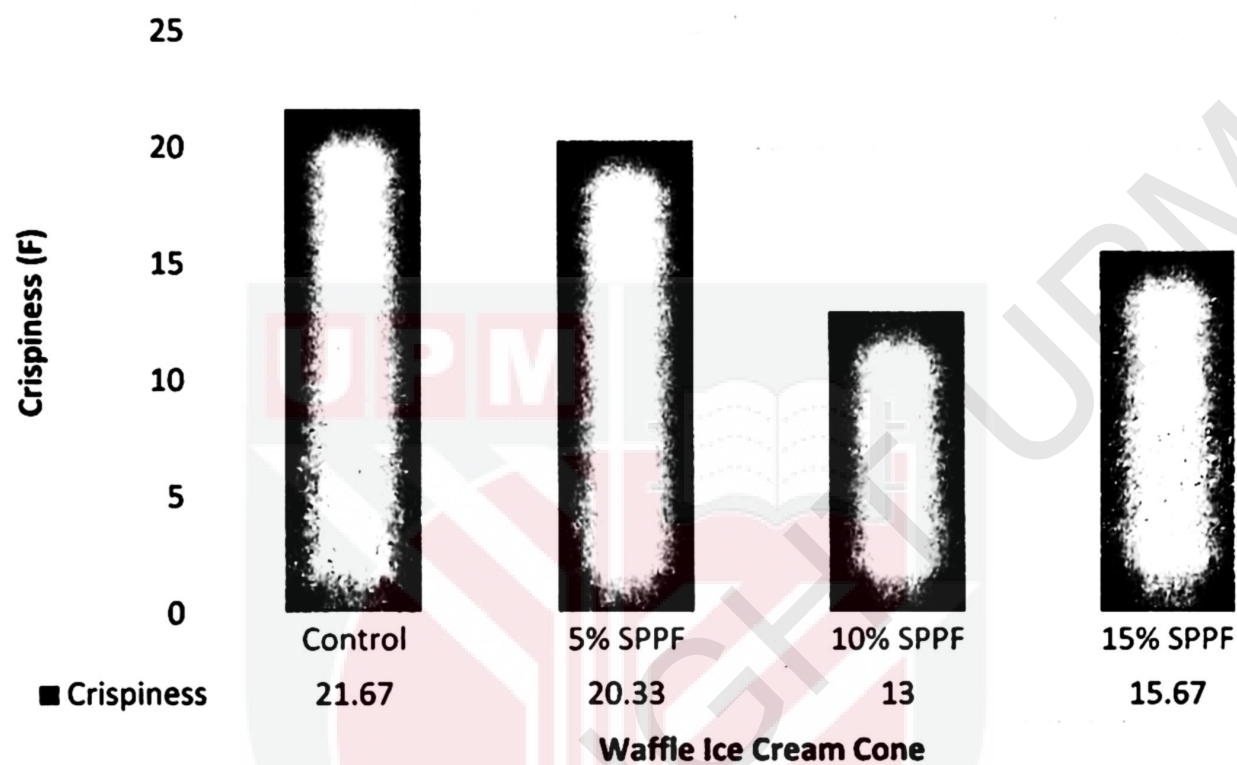


Figure 4.5 – The crispiness of waffle cones

The last parameter being analyzed by the texture analyzer was the crispiness of the waffle ice cream cones texture. The crispiness of the waffle ice cream cone is one of the main attractions of customers towards the waffle ice cream cones. From the result in Figure 4.3 and Figure 4.5, these can be said that the waffle cones with the highest crispiness will have the lowest brittleness of the waffle cones texture, where the brittleness was the opposite side to the crispiness.

From Figure 4.5, the control sample of waffle ice cream cone gave the highest result of crispiness while the result for the crispiness with an addition of sweet potato peel flour (SPPF) decreases. This happened due to the higher water and oil holding capacity of

the sweet potato peel flour (SPPF). As the water is retained in the flour, it increases the moisture on the batter preparation then results in the less crispiness of the waffle ice cream cone after being cooked. Higher result of oil holding capacity of the sweet potato peel flour, the oil remains within the structure softening the texture of the waffle ice cream cone and thus reducing the crispiness of the waffle ice cream cone.

Variation in the result of all control and sweet potato peel flour (SPPF) substitutions were depending on the size of the manually folded cone shape of the waffle ice cream cone, the type of packaging used to pack the waffle cones, the time exposure of the waffle cone to the environment and the different batches of sweet potato peel flour (SPPF) produced when making the batter. These errors can be reduced by improving the way of handling the experiment by folding the cone-shape using the standard folded cone-shape, use tight packaging to pack the waffle cone and run the experiment in the same day to reduce any error happen towards the waffle cones.

Table 4.9 also shows the result for the moisture content of the waffle cones. The moisture content for the freshly baked waffle cones should be below 2%. From the experiment, the result of moisture content for the control and 5% SPPF waffle cones is below 2% which shows that the waffle cones texture is crispy. The less moisture content in the waffle cones, the higher the crispiness of the waffle cones. For the 10% SPPF and 15% SPPF waffle cones, the result of moisture content exceeds 2% of moisture. This higher moisture content for both waffle cones due to the higher water holding capacity (WHC) of sweet potato peel flour (SPPF) as the ingredient in the making of waffle cones. The high percent of water holding capacity (WHC) has influenced the moisture content of the waffle cones.

#### 4.4 LAB colour analysis

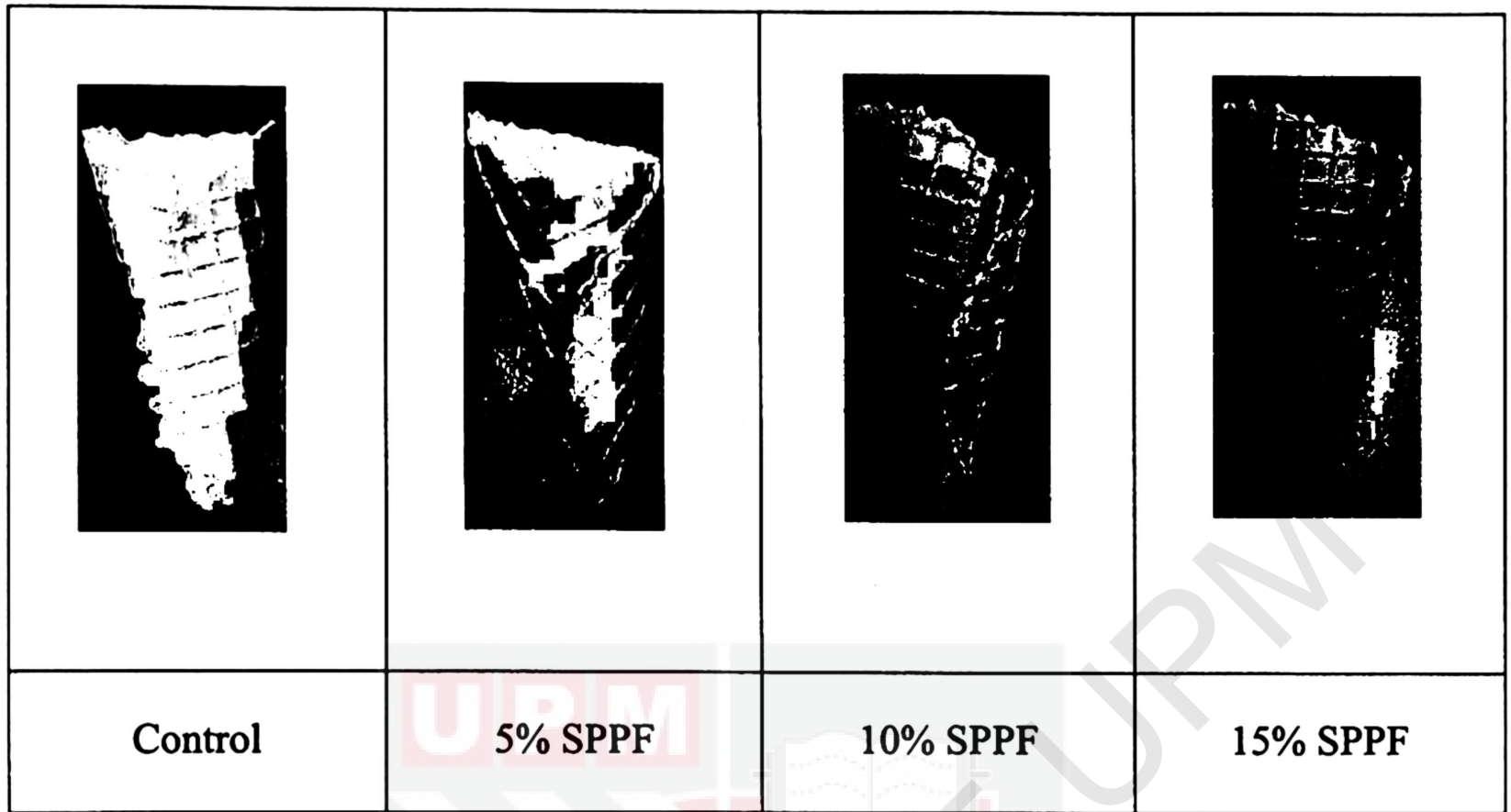


Figure 4.6 – Colour different of waffle cones

	<b>L*</b>	<b>a*</b>	<b>b*</b>
<b>Control</b>	27.57 ± 0.15	11.4 ± 0.6	29.8 ± 6.33
<b>5% SPPF</b>	27.37 ± 2.15	16.97 ± 9.39	22.27 ± 8.37
<b>10% SPPF</b>	24.07 ± 0.59	11.27 ± 0.74	29.60 ± 6.46
<b>15% SPPF</b>	23.30 ± 0.70	9.03 ± 0.60	31.77 ± 3.07

SPPF = Sweet Potato Peel Flour

Table 4.10 – The L\*a\*b\* colour analysis

Table 4.10 shows the result for the  $L^*a^*b^*$  colour analysis of the waffle cones.  $L^*a^*b^*$  colour analysis was defined by the International Commission on Illumination (CIE) in 1976. It expresses colour as three values.  $L^*$  is for the lightness from black ( 0 ) to white ( 100 ),  $a^*$  from green ( - ) to red ( + ), and  $b^*$  from blue ( - ) to yellow ( + ). It is designed to have the same amount of numerical change in these values corresponds to roughly the same amount of visually perceived change.

The result of  $L^*$  values decreases as the substitution of the sweet potato peel flour increase. Based on the result from Table 4.10, it shows that the colour of the waffle cone increase in its darkness where the 15% SPPF has the lowest of  $L^*$  values. Low of  $L^*$  values showed that the surface colour of waffle cones move towards the dark in colour while the control waffle cone gave the result of highest in  $L^*$  values thus the colour of the waffle cones were reducing in its darkness. The darkness of the waffle cones for the waffle cones with the substitution of sweet potato peel flour (SPPF) came from the colour of the sweet potato peel flour itself. The colour of the flour was dark in colour same as the original colour of the sweet potato peel. This sweet potato peel colour had affected the colour of the sweet potato peel flour and also the colour of the batter of the waffle cones. Thus it gave the outcome of the waffle cones increases dark in colour.

The  $a^*$  values shown the colour changed from green to red. From the result in Table 4.10, 5% SPPF gave the result of high of  $a^*$  values. This higher value has shown that the waffle cones colour moving to the red. The  $a^*$  values changed for the waffle cones with the sweet potato peel flour (SPPF) substitution decreases in its values. This decreasing values showed that the waffle cones colour moving to green in colour. For  $b^*$  values, it measured from blue to yellow colour changed on the waffle cones. From the

result shown in Table 4.10 above, it showed the increasing of  $b^*$  values for the waffle cones with the substitution of sweet potato peel flour (SPPF). Increasing  $b^*$  values means the colour of the waffle cones moving to yellow colour. These colour changed only can be measured using the  $L^*a^*b^*$  colour determination equipment such as the spectrophotometer.

The  $L^*a^*b^*$  colour values measured for the waffle cones do not give the nice result values based on the increasing amount of substitution sweet potato peel flour (SPPF) because these waffle cones colour also influenced by the cooking time of the waffle cones and the thickness of the waffle cones. The thin waffle cones tent to have a darker colour of waffle cones although the cooking time was set at the same. Therefore, triplicate has been done for every waffle cones samples to get an average result of the  $L^* a^* b^*$  colour.

## 4.5 Sensory evaluation

The sensory evaluation test is done on the new food product mainly to know the acceptance of the consumers towards the new products. The making of waffle cones with the substitution of sweet potato peel flour in the batter formulation was the innovation done in the making of waffle cones in its ingredients. There were 20 respondents involved in the sensory evaluation of this new formulation of waffle cones consisting of various age groups. The result of this sensory evaluation is tabulated in the pie chart above. Five aspects being asked in the sensory test of the waffle cones which are the colour appearance, aroma, taste, crispiness and the overall acceptability of the waffle cones by the respondents. The result for the sensory evaluation shown in Figure 4.7.

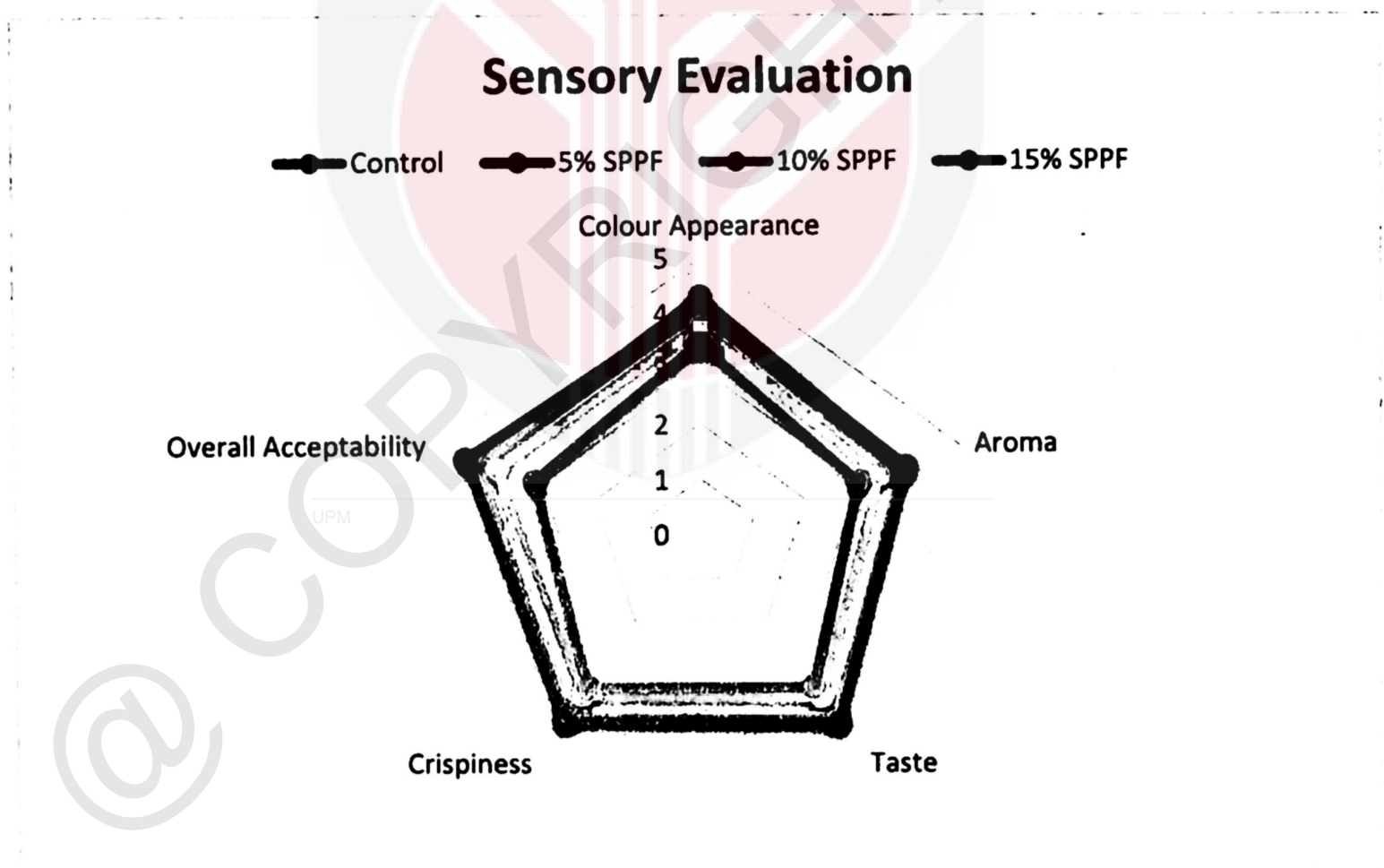


Figure 4.7 – Result for sensory evaluation

From the result on Figure 4.7, the control sample have the highest percentage acceptance by the respondents followed by the 5% SPPF of waffle cones have the percentage of acceptance of waffle cones colour by the respondents. The 15% SPPF waffle cones have the lowest colour acceptance by the respondents on the waffle cone. This is because the increasing amount of sweet potato peel flour (SPPF) in the batter formulation affects the waffle cones colour by producing the dark colour of waffle cones. The respondents may not like the dark colour of the waffle cones as it gave the impression that the waffle cones had a bitter taste due to the overcook of waffle cones.

The second question being asked was the aroma of the waffle cones. From the result in Figure 4.7, the control sample of waffle cones has the highest percentage of acceptance by the respondents followed by the 5% SPPF waffle cones. The result has shown that the respondents are attracted to the waffle cones with the small substitution of sweet potato peel flour (SPPF) only. This is because a large amount of sweet potato peel flour (SPPF) gave an uncomfortable aroma when eat. Besides, the combination of ice cream with the waffle cones made was not suitable. Therefore it is less accepted by the respondents.

The third question was on the taste of the waffle cones. From the evaluation done towards the respondents, the most accepted taste by them was the 5% SPPF substitution. Most of the respondents like the waffle cones with just a little aroma and taste of the sweet potato peel. For the increasing of sweet potato peel flour (SPPF) substitute in the batter, it gave a result of less acceptance by the respondents the same as the result obtained for the

aroma acceptance. This is because the aroma and the taste of the waffle cone were influenced by each other. The good aroma eventually gave a nice taste to eat. As the aroma was not very good for a large amount of sweet potato peel flour (SPPF) substitution, this also affects taste acceptance.

Next question on the crispiness of the waffle cone. The crispiness is one of the most things that need to be considered in the making of waffle cones. From Figure 4.7, the result showed the 5% SPPF substitution in the batter had the highest crispiness acceptance by the respondents. Same as the result for aroma and taste sensory evaluation, the increasing amount of sweet potato peel flour (SPPF) gave the result of less acceptance by the respondents. In the context of crispiness, the texture of for 10% SPPF and 15% SPPF had lower crispiness compared to the control and 5% SPPF waffle cone. The lower crispiness of the increasing amount of sweet potato peel flour (SPPF) was due to the high water and oil holding capacity of the sweet potato peel flour. The water and oil remain in the flour caused the texture of the waffle cones a little bit moist and less crispy.

From the sensory evaluation done, the overall acceptability of the waffle cones by the respondents shown in Figure 4.7. From the result, 5% SPPF substitution had the highest acceptability by the respondents according to its colour, aroma, taste and crispiness of the waffle cones. Thus the successful substitution of sweet potato peel flour (SPPF) in the making of waffle cones only for the 5% SPPF substitution.

## **4.6 The shelf life of waffle cones**

One of the things that need to consider in making food products is the shelf life or the expired date of the products. This is important to make sure the foods are safe to eat. In the making of waffle cones for ice cream, the longer shelf life would be more efficient. Besides, the waffle cones are the dried food products, thus the shelf life can be longer than the other wet food products.

### **4.6.1 The physical appearance of waffle cones**

The two things that are considered on the physical appearance of the waffle cones are the colour of the waffle cones and the growth of microorganisms on the waffle cones. The picture of the waffle cones shown in Figure 4.12 and Figure 4.13.



**Figure**

**Figure 4.8 – The colour of the waffle cones at the early production**



**Figure 4.9 – The colour of waffle cones after 8 months**

The colour change observation has been done for waffle cones after 8 months from its production date by observing the physical appearance of the waffle cone. From the observation of Figure 4.8 and Figure 4.9, it shows that the colour of the waffle cones does not change after 8 months. From this result, the colour of the waffle cones can be maintained for a longer period. This will be an advantage in this waffle cone to have a good appearance after sometime.

The growth of microorganisms on the food products can cause the spoiled on the food. The product with high moisture content enhanced the faster growth of microorganisms. For this waffle cones, there was no growth of microorganisms on the surface of waffle cones after 8 months it being cooked. It because the waffle cone is the dried products, therefore it lengthens the time for microorganisms growth. This proved that this making of waffle cones with the substitution of sweet potato peel flour (SPPF) was successful because it safe from harmful microbes by having a longer shelf life.

## 4.6.2 Texture analysis of waffle cones

### 4.6.2.1 Hardness

Sample	0 months	2 months	4 months	8 months
Control	3.35 ± 0.88	3.11 ± 0.40	2.75 ± 0.35	2.54 ± 0.47
5% SPPF	7.47 ± 2.20	6.94 ± 1.01	5.70 ± 0.44	4.44 ± 0.69
10% SPPF	9.12 ± 6.62	8.45 ± 0.76	6.57 ± 0.49	6.11 ± 0.62
15% SPPF	5.77 ± 2.57	4.92 ± 0.64	3.94 ± 0.38	3.53 ± 0.65

Table 4.11 – Hardness value of waffle cones

Table 4.11 shows the hardness of the waffle cones after 2 months, 4 months and 8 months from the date of production. The result of hardness for all samples including the control, 5% SPPF, 10% SPPF and 15% SPPF shows the decreasing value of the hardness in the increasing time. This is because the texture of the waffle cones slowly became soft during the increasing of storage time. The moisture could enter the storage container slow which reducing the hardness of the waffle cones. Therefore, the waffle cones will be less attractive to eat.

#### 4.6.2.2 Brittleness

Sample	0 months	2 months	4 months	8 months
Control	3.51 ± 1.65	3.89 ± 1.04	4.21 ± 0.36	4.46 ± 0.52
5% SPPF	3.57 ± 0.99	3.87 ± 0.67	4.49 ± 0.57	4.61 ± 0.53
10% SPPF	3.92 ± 1.81	4.40 ± 0.43	4.60 ± 0.54	5.36 ± 0.89
15% SPPF	3.75 ± 0.69	4.28 ± 0.41	4.73 ± 0.35	5.16 ± 0.57

Table 4.12 – Brittleness value of waffle cones

The result in Table 4.12 shows the brittleness of the waffle cones. The result of the brittleness of the waffle cones shows an increasing pattern in the increasing period of storage. The higher brittleness value shows that the waffle cones need more force for the waffle cones to start brittle. More force needed shows that the waffle cones less crispy and it needs more time for the crack to occur. 5% SPPF, 10% SPPF and 15% SPPF have higher brittleness value compared to the control waffle cones. This shows that the addition of sweet potato peel flour (SPPF) as the ingredients in the making of waffle cones affect the brittleness of the waffle cones.

### 4.6.2.3 Toughness

Sample	0 months	2 months	4 months	8 months
Control	3.60 ± 0.62	2.44 ± 0.41	1.96 ± 0.63	1.73 ± 0.55
5% SPPF	8.40 ± 5.55	7.58 ± 0.90	7.29 ± 0.74	7.11 ± 1.74
10% SPPF	8.49 ± 9.60	7.51 ± 0.65	7.18 ± 1.04	6.81 ± 1.16
15% SPPF	4.97 ± 1.54	5.13 ± 0.37	5.33 ± 0.41	5.68 ± 0.37

Table 4.13 – Toughness value of waffle cones

Table 4.13 above shows the result for the toughness of the waffle cones from the date of production until 8 months. The result for control, 5% SPPF and 10% SPPF waffle cones show the decreasing value of toughness while the 15% SPPF shows an increasing value of toughness. However, the increasing value of toughness for the 15% SPPF only in the small range. The toughness of the waffle cones should be reduced as the increasing time where the waffle cones may expose to the surrounding humidity during the storage period.

#### 4.6.2.4 Crispiness

Sample	0 months	2 months	4 months	8 months
Control	21.67 ± 5.86	18.24 ± 1.71	14.74 ± 0.86	12.87 ± 0.95
5% SPPF	20.33 ± 2.52	18.13 ± 0.77	14.27 ± 1.50	9.43 ± 0.62
10% SPPF	13.00 ± 9.17	11.67 ± 0.72	10.45 ± 0.53	7.09 ± 0.40
15% SPPF	15.67 ± 10.0	12.43 ± 0.94	9.27 ± 1.67	6.48 ± 1.24

Table 4.14 – Crispiness value of waffle cones

Table 4.14 shows the crispiness value of the waffle cones for four different samples. From the value obtained, the crispiness of the waffle cones shows the decreasing pattern where this result shows that the waffle cones have reducing its crispiness. The crispiness of the waffle cones could be reduced if it exposed to the surrounding moisture. Besides, the sweet potato flour (SPPF) that is used as the ingredients in the making of waffle cones also high in water and oil holding capacity which can also be the factor for this reduction of waffle cones crispiness.

The 15% SPPF waffle cones have the lowest value of crispiness as the texture of the waffle cones becomes soft after a certain period. An increasing amount of sweet potato peel flour (SPPF) added in the batter formulation increasing the water holding content (WHC). Therefore it caused the waffle cones to become soft due to the water and oil retention in the waffle cones after baking.

#### 4.6.2.5 Moisture content

Sample	0 months	2 months	4 months	8 months
Control	1.57 ± 0.13	4.30 ± 0.85	6.90 ± 0.94	9.18 ± 0.17
5% SPPF	1.98 ± 0.33	3.78 ± 0.51	7.00 ± 0.69	9.36 ± 0.66
10% SPPF	2.77 ± 0.25	5.74 ± 0.45	7.06 ± 0.84	9.37 ± 0.61
15% SPPF	3.1 ± 0.42	6.40 ± 0.56	9.12 ± 0.52	10.40 ± 0.57

Table 4.15 – Moisture content of waffle cones

Table 4.15 shows the moisture content of the waffle cones. This moisture content analysis is important to maintain the shelf life of the product. The higher moisture content in the product will enhance the growth of microorganisms and shorten the shelf life of the waffle cones. The moisture content of the waffle cones between 6 to 12 % shows the texture of waffle cones start to become soft. The moisture content of the waffle cones after 8 months increases. The 15% SPPF waffle cones have the highest moisture content, thus it resulted in the lowest crispiness of the waffle cones.

## **CHAPTER 5**

### **CONCLUSIONS AND RECOMMENDATION**

#### **5.1 Conclusion**

The objectives of the study were achieved. The sweet potato peel flour (SPPF) consists of nutritional value such as protein, fiber and carbohydrate which is beneficial for human health. But, the carbohydrate content for the sweet potato peel flour (SPPF) is the lowest compared to the purple-fleshed peel flour and banana peel flour where this lower carbohydrate content suitable for people with a healthy lifestyle or on diet. The proximate analysis was also done and got the result of protein 13.8%, fat 13.50%, ash 17.87%, crude fiber 3.99%, moisture content 8.56% and carbohydrate of 47.38%.

The result of texture analysis also different for every batch of waffle cones. From the result, the substitution of sweet potato peel flour (SPPF) increased the strength of the waffle cones structures on the hardness and the toughness of the waffle cones. The substitution of sweet potato peel flour (SPPF) has increased the hardness and toughness of the waffle. The brittleness of the waffle cones gives the opposite result of crispiness. The lower brittleness of the waffle cones shows the higher crispiness or the waffle cones.

Besides, the large amount of addition of sweet potato peel flour (SPPF) also affects the aroma and the taste of the waffle cones wherefrom the sensory evaluation is done shown the result that the respondents do not fully can accept the aroma and taste with a large amount of sweet potato peel flour (SPPF). Only a small substitution of sweet potato peel flour (SPPF) suitable and accepted by the respondents. Thus, for the overall acceptability of the sweet potato peel waffle cones, the 5% of SPPF substitution acceptance by the respondents.

The additional sweet potato peel flour (SPPF) substituting to the wheat flour in the waffle cones batter formulation affects the quality of the waffle cones. In the whole view, each sample started from control waffle cones and each three partial substitution sweet potato peel waffle cones (5%, 10% and 15% sweet potato peel flour substitution) were having a different colour, crispiness and taste. Besides, the addition of sweet potato peel flour (SPPF) in the batter formulation of making waffle ice cream cones gave the dark colour appearance of the waffle cones. The littlest substitution of sweet potato peel flour (SPPF) was 5% and 95% of wheat flour. The middle amount of substitution was 10% of sweet potato peel flour (SPPF) with 90% of wheat flour. The greatest substitution of sweet potato peel flour (SPPF) was 15% with 85% of wheat flour. From the study, the increased amount of sweet potato peel flour (SPPF) substitute in the batter, the increased the darkness of the waffle cones colour.

Furthermore, due to the high water and oil holding capacity (WHC and OHC) of the sweet potato peel flour, this flour can be more suitable for the use of other food products. For the high water holding capacity, the flour suitable for making viscous foods

such as bakery products and for having high oil holding capacity, it suitable for making meat-based products.

Lastly, the sweet potato peel waffle cones can be last for a period by not changing its colour and also no growth of microorganisms on the waffle cones surface. But good moisture barrier packaging and suitable storage process do help to extend the waffle cones shelf life. Besides, this project also gave a big chance to solve the waste problems involving the sweet potato peel in the industry as well as safe the environment from pollution.



## **5.2 Recommendation**

The utilization of sweet potato peel flour to waffle cones product is such an innovative approach to have a better world. There are a few recommendations that can be done to improve this study.

Firstly, the cone-shaped of sweet potato peel waffle cones must have a similar shape so that the experimental results for the texture analysis of the waffle cones will be smooth to interpret. This can be done by using the folded cone-shaped utensils to get the same cone-shaped. In addition, the waffle also easy to fold while still in hot conditions after the baking process. Besides, the irregular shape and thickness of the waffle cones have a little hole at the tip of the cone. This caused the melted ice cream flow on the hand and feeling sticky. This problem can be prevented by adding the hardened chocolate at the tip of the waffle cones.

Secondly, the good storage and packaging system of waffle cones are important to make sure the waffle cones can withstand for a longer period as well as maintaining the texture or the crispiness of the waffle cones. The good handling of the baked waffle cones considered to make sure the waffle cones are in perfect condition especially when it is used to run the experiment to get accurate results.

Last but not least, more experimental approaches that can be done to get a deeper knowledge in this study, for example of response surface methodology (RSM) and scanning electron-microscopic (SEM) analysis. This further study on this sweet potato peel flour can create more beneficial products from the waste of products.

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## APPENDICES

### i. Proximate analysis

#### Protein

$$\% \text{ of Nitrogen} = \frac{(I_s - I_b) \times N \times 1.4}{W}$$

$$\% \text{ of Protein} = \% \text{ Nitrogen} \times \text{conversion factor}$$

Sample of flour	Blank	Sample 1	Sample 2	Sample 3
Initial weight of sample, W (g)	-	0.1510	0.1508	0.1515
Volume H <sub>2</sub> SO <sub>4</sub> to titrate boric acid, I <sub>s</sub> (ml)	-	4.8	5.1	5.0
Volume H <sub>2</sub> SO <sub>4</sub> to titrate blank, I <sub>b</sub> (ml)	0.2	0.2	0.2	0.2
Normality of H <sub>2</sub> SO <sub>4</sub> , N	0.05	0.05	0.05	0.05
% of Nitrogen	2.132	2.132	2.275	2.218
% of Protein	13.325	13.325	14.219	13.863
Average reading of protein (%)	13.80			

## Fat

$$\% \text{ of oil sample} = \frac{M}{W} \times 100$$

Sample of flour	Sample 1	Sample 2	Sample 3
Weight of sample, W (g)	3.0022	3.0033	3.0008
Weight of oil, M (g)	0.3455	0.3920	0.4369
Fat content (%)	12.28	13.67	14.56
Average fat content (%)	13.5		

## Ash

$$\% \text{ Ash} = \frac{(\text{Weight of ash+crucible}) - \text{weight of crucible}}{\text{Weight of sample}} \times 100$$

Sample of flour	Sample 1	Sample 2	Sample 3
Initial weight of sample (g)	3.0012	3.0015	3.0040
Weight of crucible (g)	56.6980	59.6134	56.6955
Weight of crucible + ash (g)	57.2391	60.1584	57.2187
Ash content (%)	18.03	18.16	17.42
Average ash content (%)	17.87		

## Crude fiber

$$\% \text{ of Crude Fiber} = \frac{(S-K)-A}{W} \times 100$$

Sample of flour	Sample 1	Sample 2	Sample 3
Weight of sample, W (g)	2.0019	2.0014	2.0027
Weight of filter paper without ash, K (g)	0.3651	0.3645	0.3732
Weight of crucible + filter paper + dried residue, S (g)	57.1397	57.1194	56.4781
Weight of crucible + ash, A (g)	56.7137	56.7091	56.0520
Crude fiber content (%)	3.042	2.288	2.641
Average of crude fiber content (%)	3.99		

### ii. Sensory evaluation form

Instructions: Please circle the number that best fits your description

1 – Low, 5 - Excellent

#### i. Appearance colour of waffle cones

	1	2	3	4	5
Control					

5% SPPF					
10% SPPF					
15% SPPF					

**ii. Aroma of the waffle cones**

	1	2	3	4	5
Control					
5% SPPF					
10% SPPF					
15% SPPF					

**iii. Taste of waffle cones**

	1	2	3	4	5
Control					
5% SPPF					
10% SPPF					
15% SPPF					

**iv. Crispiness of the waffle cone**

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Control</b>					
<b>5% SPPF</b>					
<b>10% SPPF</b>					
<b>15% SPPF</b>					

**v. Overall acceptability of the waffle cone**

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Control</b>					
<b>5% SPPF</b>					
<b>10% SPPF</b>					
<b>15% SPPF</b>					