Physicochemical Properties and Sensory Evaluation of Cracker Made from Broccoli (*Brassica oleracea*)

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

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DECLARATION

I hereby declare that the work embodied here is the result of my own research except for the excerpt as cited in the references.

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ABSTRACT

Broccoli (*Brassica oleracea*) contains many high nutrients such as folic acid, potassium, and vitamins. For example, vitamin C is good to prevent cancer and heart disease while vitamin K is good to lower blood pressure. This research project was conducted to determine the physical properties and proximate composition of crackers which broccoli is one of the ingredients. There were two types of texture analysis; hardness and fracturability, which were conducted by using the texture analyzer. The results from the analysis showed a decreasing pattern with increasing broccoli concentration in broccoli crackers. Besides, the color attributes of chromatic parameters (L*, a*, and b*) were tested using the chromameter. The test results showed unstable pattern results with the increasing percentage of broccoli concentration, especially for a* (redness). For proximate analysis, as the broccoli concentration of broccoli cracker increases, the results are also unstable. Furthermore, this research project was conducted to analyze the consumers' acceptability towards broccoli cracker sensory properties in terms of its color, texture, taste, and aroma from a different concentration of broccoli. The crackers were baked by adding different concentrations of broccoli (0%, 2%, 4%, 6%, and 8%), respectively, in the cracker dough. From the sensory evaluation conducted by 35 panelists, the result showed that the broccoli cracker with 2% of broccoli concentration was the most preferred based on the hedonic scale rating for sensory evaluation. Although most of the panelists gave a score 3 (like) for broccoli crackers in sensory evaluation, the result of P-value in ANOVA for the overall acceptance of broccoli crackers was not significant between the concentration on consumer acceptability. Therefore, the null hypothesis was accepted, and the objective of this study was not achieved.

Keywords: Broccoli, *Brassica oleracea*, physicochemical properties, sensory evaluation, consumers' acceptability.

ABSTRAK

Brokoli (Brassica oleracea) mengandungi banyak nutrien yang tinggi seperti asid folik, kalium, dan vitamin. Sebagai contoh, vitamin C baik untuk mencegah kanser dan penyakit jantung manakala vitamin K baik untuk menurunkan tekanan darah. Projek penyelidikan ini dijalankan untuk menentukan sifat fizikal dan komposisi proksimat keropok yang mana brokoli merupakan salah satu ramuannya. Terdapat dua jenis analisis tekstur; kekerasan dan kepatahan, yang dijalankan dengan menggunakan penganalisis tekstur. Hasil daripada analisis menunjukkan corak menurun dengan peningkatan kepekatan brokoli dalam keropok brokoli. Selain itu, atribut warna parameter kromatik (L*, a*, dan b*) telah diuji menggunakan kromameter. Keputusan ujian menunjukkan keputusan corak yang tidak stabil dengan peningkatan peratusan kepekatan brokoli, terutamanya untuk a* (kemerahan). Untuk analisis proksimat, apabila kepekatan brokoli keropok brokoli meningkat, hasilnya juga tidak stabil. Selain itu, projek penyelidikan ini dijalankan untuk menganalisis kebolehterimaan pengguna terhadap sifat deria keropok brokoli dari segi warna, tekstur, rasa dan aroma daripada kepekatan brokoli yang berbeza. Keropok itu dibakar dengan menambahkan kepekatan brokoli yang berbeza (0%, 2%, 4%, 6%, dan 8%), masing-masing dalam adunan keropok. Daripada penilaian deria yang dijalankan oleh 35 ahli panel, keputusan menunjukkan bahawa keropok brokoli dengan kepekatan 2% brokoli adalah yang paling digemari berdasarkan penarafan skala hedonik untuk penilaian deria. Walaupun kebanyakan panelis memberikan skor 3 (suka) untuk keropok brokoli dalam penilaian deria, keputusan nilai P dalam ANOVA untuk penerimaan keseluruhan keropok brokoli adalah tidak signifikan antara kepekatan kebolehterimaan pengguna. Oleh itu, hipotesis nol telah diterima, dan objektif kajian ini tidak tercapai.

Kata kunci: Brokoli, *Brassica oleracea*, sifat fizikokimia, penilaian deria, kebolehterimaan pengguna.

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LIST OF SYMBOLS AND ABBREVIATIONS

		Page
oz	Ounce	8
µg	Microgram	8
mg	Milligram	8
g	Gram	8
kJ	Kilojoule	8
kcal	Kilocalorie	8
IU	International Unit	9
NaOH	Sodium hydroxide	12
HCl	Hydrochloric acid	12
˚C	Degree Celcius	12
cm	Centimeter	13
ml	Mililiter	13
CIE	Commission Internationale de l'Eclairage	14
mm/s	Milimeter per second	14
SPSS	Statistical Package for the Social Science	19
ANOVA	One-Way-Analysis of Variance	19
TPA	Texture Profile Analysis	24
CO_2	Carbon dioxide	31
N_2	Nitrogen	31

CHAPTER 1

INTRODUCTION

1.1 Research Background

Food is a fundamental human need, and a person needs to choose nutritious foods to eat. Commonly, foods are made from animal, plant, or fungal, which contain many important nutrients such as protein, carbohydrates, fats, and vitamins.

Broccoli, also known as *Brassica oleracea*, was originally from Italy more than 2,000 years ago. Broccoli newly planted takes 100 to 150 days to mature. Broccoli grown from transplants will be ready to harvest in 55 to 80 days. Broccoli contains antioxidant compounds that can be used to reduce blood sugar and decrease cholesterol levels. A cracker is a crisp, flat-baked food made mainly with flour. Crackers are often sold as a healthy and easy way to obtain a staple food. It is also known as having low fat and sugar. This research project is conducted to analyze the consumers' acceptability towards broccoli cracker sensory properties. The combination of broccoli and crackers would affect the crackers' color, texture, taste, and aroma.

1.2 Problem Statements

Broccoli usually consumed cooked such as broccoli spinach soup and stir-fried with other vegetables. However, many people did not like to eat broccoli because of its grassy, earthy flavour and slightly bitter taste. This research was conducted to analyze the consumers' acceptability towards crackers that mixed with different broccoli concentration in the crackers' dough. Besides, the nutritional values in crackers made from broccoli might be different between other common crackers. Thus, this research was conducted to analyzed nutritional values of crackers made with broccoli.

1.3 Objectives

1. To determine the physicochemical properties of crackers made from broccoli.
2. To analyze the consumers' acceptability towards broccoli cracker sensory properties.

1.4 Hyphothesis

H_0 : There is no significant difference between the broccoli concentration in the crackers on consumer acceptability.

H_1 : There is a significant difference between the broccoli concentration in the crackers on consumer acceptability.

1.5 Scope of Study

This research focuses on the physical properties, proximate analysis, and sensory acceptability of the cracker when broccoli is added to the cracker as one of its ingredients. The broccoli will be obtained from a nearby mall. The physical properties of broccoli crackers will be tested after adding broccoli into the dough of the cracker. Furthermore, for the sensory evaluation, data will be gathered from a random of 35 students at UMK. The selected respondents will assess the color, texture, taste, aroma, and overall acceptance of the crackers.

1.6 Significance of Study

Broccoli is a healthy vegetable that can be consumed raw or prepared. Unfortunately, many people do not like broccoli especially kids. By doing this research project, a solution can be obtained to solve this problem.

1.7 Limitation of Study

The limitation of this research is that broccoli can be purchased in a supermarket, however, as a student, it is hard to purchase the broccoli because a vehicle is not provided. Furthermore, to complete this project, the students need to buy raw materials by themselves, which might cost a lot. Next is the hurdle when baking the crackers. The kitchenware such as oven and blender to make the crackers are not enough where students need to use it in turn. Besides, during performing proximate analyses, there were technical

issues in UMK where there were no water and electricity. This cause the delay in completing the test and students need to redo the test as their test and samples are can no longer be used. Lastly, for the sensory evaluation, it was only limited to 35 students at UMK. Thus, this makes the data collected are not completely reliable since this research project conducted in not a wide reach in terms of regional and particular geographic.

CHAPTER 2

LITERATURE REVIEW

2.1 Broccoli (*Brassica oleracea*).

Broccoli (Figure 2.1) comes from the family Brassicaceae, genus *Brasicca* and species of *Brassica oleracea*. It is originally from Italy for more than 2,000 years. Broccoli can grow 24–35 inches (60–90 cm) tall. Depending on the weather, broccoli can be harvested in 60 to 150 days. There are a few other cultivar groups of *B.oleracea* such as Chinese broccoli/kai lan (Figure 2.2) from Alboglabra group, and Romanesco broccoli (Figure 2.3) from Botrytis Group.

Figure 2.1 Broccoli (*Brassica oleracea*)

Figure 2.2 Chinese broccoli/kai lan

Figure 2.3 Romanesco broccoli

Based on Table 2.1, the broccoli production in 2019, global broccoli production in 2019 was 27 million tonnes (combined for production reports with cauliflowers), with China and India accounting for 73%. The United States, Spain, and Mexico were secondary producers, producing around one million tonnes or less per year. Broccoli is

grown year-round in California, which grew 92% of the national crop in 2018, with 95 percent of the total crops grown for initial sales (FAOSTAT of the United Nations, 2020).

Broccoli production -2019 (includes cauliflower)	
Country	**Production** millions of tonnes
China	10.6
India	9.1
United States	1.2
Spain	0.7
Mexico	0.7
World	**26.9**

Source: FAOSTAT of the United Nations

Table 2.1 Broccoli production in 2019

2.2 Nutritional Composition of Broccoli.

Broccoli is a healthy vegetable rich in dietary fiber and a variety of vitamins and minerals, including folic acid, potassium, and vitamins A, C, and K. It can be consumed raw or cooked. Vitamin C and Vitamin K can prevent cancer and heart disease and lower blood pressure.

A 100 gram serving of raw broccoli contains 34 calories and is a good source of vitamin C (107% DV) and vitamin K (97% DV). A few B vitamins and the nutritional mineral manganese are moderately abundant (10–19% DV) in raw broccoli, while other

micronutrients are scarce (less than 10% DV). Raw broccoli comprises 89% of water, 7% of carbohydrates, 3% of protein, and very little fat. Broccoli is also high in fiber, making it beneficial for weight loss.

Broccoli, raw		
Nutritional value per 100 g (3.5 oz)		
Energy	141 kJ (34 kcal)	
Carbohydrates	6.64 g	
Sugars	1.7 g	
Dietary fiber	2.6 g	
Fat	0.37 g	
Protein	2.82 g	
Vitamins	**Quantity**	**% DV[+]**
Vitamin A equiv.	31 µg	4%
beta-Carotene	361 µg	3%
lutein zeaxanthin	1403 µg	
Thiamine (B_1)	0.071 mg	6%
Riboflavin (B_2)	0.117 mg	10%
Niacin (B_5)	0.639 mg	4%
Pantothenic acid (B_5)	0.573 mg	11%
Vitamin B_6	0.175 mg	13%
Folate (B_9)	63 µg	16%
Choline	19 mg	4%

Vitamin C	89.2 mg	107%
Vitamin E	0.78 mg	5%
Vitamin K	101.6 µg	97%
Minerals	**Quantity**	**% DV^{+}**
Calcium	47 mg	5%
Iron	0.73 mg	6%
Magnesium	21 mg	10%
Manganese	0.21 mg	9%
Phosphorus	66 mg	7%
Potassium	316 mg	2%
Sodium	33 mg	4%
Zinc	0.41 mg	
Other constituents	**Quantity**	
Water	89.3 g	

Units µg = micrograms mg =milligrams IU = International units
Percentages are roughly approximated using US recommendations for adults. Source: USDA FoodData Central

Table 2.2 Nutritional value of raw broccoli per 100 g

2.3 Sensory Properties of Food

The most crucial aspect people consume the foods they eat is their sensory properties. Food's appearance, taste, texture, and even sounds can stimulate a desire to eat or cause us to reject the food as unappealing, outdated, or even culturally inappropriate. Consumers would like to have their food be nutritious, but when it comes in making a purchasing decision, the taste is the most important factor. Via our senses of touch, taste, smell, hearing, and sight, we feel the pleasure of feeding. According to Galvez & Resurrection (1992), the acceptance of a product's overall acceptability by frequent users of the product category is referred as sensory property. Examples of sensory properties are colour, flavour, mouthfeel, and aroma. There are 5 main sensory properties of food which are texture, colour, scent, taste, and also appearance.

CHAPTER 3

METHODOLOGY

3.1 Materials

3.1.1 Raw Materials

The raw materials used to make the broccoli cracker were broccoli, flour, sugar, salt, butter and water.

3.1.2 Equipment

First of all, to prepare the broccoli powder, the equipment used was a food dehydrator, grinder, container, refrigerator and sealed plastic bags. Next, the equipment used to prepare broccoli crackers were a mixing bowl, spoon, fork, cutting board, cutter, roller, baking tray, parchment paper, oven, containers and sealed paper bags.

Besides, to determine protein content (Kjeldahl method), the equipment that was used were media bottles, stirrer, beakers, measuring cylinders, magnetic stirrer, Kjeldahl tubes, conical flasks, Kjeldahl auto distillation analyzer, burette, pipette, retort stand, analytical balance and glove.

Furthermore, to determine the fat content, the equipment used were aluminium cups, desiccator, oven, thimbles, cotton, Whatman filter papers, Soxtec machine and analytical balance. The equipment that has been used to determine ash content were crucibles, furnace, desiccator, and analytical balance. The equipment that has been used to determine moisture content were petri dishes, oven, desiccator and analytical balance.

The equipment has been used to test the colour attributes by using the Konica Minolta Chroma Meter. Lastly, the equipment used to test the texture attributes by using Texture Analyzer (Brookfield, CT3, USA).

3.1.3 Chemicals

Boric acid, 40% NaOH, HCl, sulphuric acid, Kjeltec powder and petroleum ether.

3.2 Methods

3.2.1 Preparation of Broccoli Powder

First of all, the broccoli was cut into small pieces. Then, it was put into the food dehydrator at a temperature of 65˚C. The small pieces of the broccoli were dehydrated for 4 hours and then taken out and weighed. After that, it was dehydrated again for another 2 hours and 30 minutes. Then, it was taken out and weighed. Lastly, grind the dehydrated broccoli using a grinder and put it in a container. If it is not being used, it will be stored in the refrigerator.

3.2.2 Preparation of Broccoli Cracker

Based on Table 3.1, the formulation of broccoli cracker with different broccoli concentrations, the broccoli crackers were prepared by mixing all the raw materials: flour, sugar, salt, butter, water, and different concentration of blended broccoli (0%, 2%, 4%, 6% and 8%). The dough was rolled around 0.3 cm in height. Then, the dough was cut into square size, 3 cm X 3 cm using a cutter. Dork each cracker with a fork and then was baked at the temperature of 180˚C for 10-12 minutes with 210˚C preheated oven for 10 minutes. Lastly, the crackers were immediately removed and cooled at room temperature.

Broccoli powder (%)	Ingredients						Total (g)
	Broccoli powder (g)	Flour (g)	Sugar (g)	Salt (g)	Butter (g)	Water (ml)	
0	0.0	100.0	10.0	2.0	6.0	45.0	163.0
2	3.26	96.74	10.0	2.0	6.0	45.0	163.0
4	6.52	93.48	10.0	2.0	6.0	45.0	163.0
6	9.78	90.22	10.0	2.0	6.0	45.0	163.0
8	13.04	86.98	10.0	2.0	6.0	45.0	163.0

Table 3.1 Formulation of broccoli cracker with different broccoli concentration

3.2.3 Determination of Physical Properties

Two physical property attributes have been tested; the colour attribute and the texture attribute. The colour attribute was tested using a Konica Minolta Chroma Meter. Three results were obtained from the chromameter, which were L*, a*, and b*. It is defined by the Commission Internationale de l'Eclairage (CIE)/International Commission Illumination The values of L*, a*, and b* were based on the CIELAB colour space. "L" denotes lightness, "a" denotes redness, and "b" denotes yellowness. Another physical property was the texture analysis. The texture was analyzed using the Texture Analyzer (Brookfield, CT3, USA). Two types of analyses were done, which are the crackers' hardness and the fracturability. The analysis was done by using the TPA test type, with the setting of probe TA7, trigger load of 5 g, and a speed of 10 mm/s.

3.2.4 Determination of Proximate Analysis

The proximate analysis done in this research were protein content, fat content, ash content and moisture content.

3.2.4.1 Protein Content

Protein content were found using the Kjeldahl method. Kjeldahl method was invented by Johan G. C. T. Kjeldahl, a Danish chemist in 1883 (Blamire, 2003).

First and foremost, 10 g of boric acid were prepared. of boric acid were weighed. Put it in the beaker containing 100 ml of distilled water. Then, stir using the magnetic stirrer with the setting of 100˚C temperature and speed number 2. Next, the boric acid was moved to the measuring cylinder. Distilled water was put into the measuring cylinder until it held 250 ml. After that, it was moved into a beaker. 1.75 ml of methyl red and 2.5 ml of bromocresol green were put into the solution using a pipette. Then, 30 ml of the solution was filled into the conical flask.

After that, for the digestion process, 1 g of sample powder was put into the Kjeldahl tube. Then, put two spoons of kjeltec powder and 12 ml of sulphuric acid in the tube. cooled for around 15 minutes after the digestion process ends.

Next, the distillation process. After the solution (from the digestion process) had cooled, 80 ml of distilled water and 50 ml of 40% NaOH were put into the tube. The machine was washed twice before starting and once after each sample. Then, the tube (containing the solution from the digestion process) and boric acid (in the conical flask) were in the Kjeldahl auto distillation analyzer (Kjeltec 8200). The "start" button was pushed and waited for 3 minutes. The chemical in the conical flask turned from red to green in colour. The process was repeated until all 15 tubes were done.

Finally, there is the titration procedure. In the titration process, HCl was prepared beforehand. The burette was filled with 50 ml of HCl. The solution was titrated until the colour changed from green to red. The reading was recorded.

The formula to find the ash percentage is as below:

$$\% \text{ Kjeldahl Nitrogen, N} = \frac{(V_s - V_b)\ X\ N\ X\ 14.01}{W\ X\ 1000} \text{ x } 100\%$$

V_s = ml of standardized acid used to titrate the sample

V_b = ml of standardized acid used to titrate blank

N = normality

W = weight of sample

Protein (%) = 6.25 x % N

3.2.4.2 Fat Content

Fat content were found using the Soxtec extraction. Soxtec extraction was invented by Franz Ritter von Soxhlet, a German chemist in 1980s.

First of all, the aluminium cups were put in the oven at a temperature of 103˚C for 30 minutes. Then, it was put in the desiccator for 20 minutes. The sample was prepared in the thimble while waiting for the aluminium to heat and cool down. The order of preparation for the sample was: the sample in the thimble was (from the bottom) cotton, 1.5 g of sample (make a cone shape with Whatman filter paper and put the sample into it) and cotton at the top.

After cooling, the aluminium cup was weighed. 80 mL of petroleum ether was put into the aluminium cup. Then, it was put into the machine. After the process was done, the aluminium cup was put in the oven at a temperature of 103˚C for 30 minutes and

cooled in the desiccator for 20 minutes. Lastly, the aluminium cup was weighed using an analytical balance and the data was recorded.

The formula to find the fat percentage is as below:

$$\text{Fat (\%)} = \frac{final\ cup\ weight - initial\ cup\ weight}{sample\ weight} \text{ x } 100\%$$

3.2.4.3 Ash Content

First of all, the crucibles and the crucibles with the sample were weighed. Total of 3 g of sample for each concentration were prepared (1 g for each crucible). Then, all the crucibles were put in the furnace at a temperature of 400˚C for 6 hours. After 6 hours, those crucibles with samples were cooled in the desiccator for 20 minutes. After that, the crucibles with the sample were weighed using an analytical balance and the data was recorded.

The formula to find the ash percentage is as below:

$$\text{Ash (\%)} = \frac{W3 - W1}{W2 - W1} \text{ x } 100\%$$

W1 = weight of the crucible

W2 = weight of crucible with sample (before)

W3 = weight of crucible with sample (after)

3.2.4.4 Moisture Content

First and foremost, the petri dishes and the petri dishes with the sample were weighed. A total of 3 g of sample for each concentration were prepared (1 g for each petri dish). Then, all the petri dishes were put in the oven at a temperature of 105˚C for 24 hours. After 24 hours, those petri dishes with samples were cooled in the desiccator for 20 minutes. After that, the petri dishes with the sample were weighed using an analytical balance and the data was recorded.

The formula to find the moisture percentage is as below:

$$\text{Moisture (\%)} = \frac{sample\ weight - dried\ weight}{sample\ weight} \times 100\%$$

Dried weight = final weight of petri dish with sample – initial weight of petri dish

3.2.4.5 Carbohydrate Content

The carbohydrate content was calculated by using the formula:

Carbohydrate (%) = 100% - [Protein (%) + Fat (%) + Ash (%) + Moisture (%)

3.2.5 Sensory Evaluation

The sensory evaluation was done to determine the consumers' acceptability towards broccoli cracker sensory properties, which were in terms of colour, texture, taste, aroma, and overall acceptance. A total of 35 students from UMK were evaluated on the broccoli cracker with a provided hedonic scale for their likeness towards the cracker. Each panellist evaluated the broccoli crackers with different concentrations. They were also given plain water to rinse their mouths before trying another broccoli cracker with a different concentration. They were given plain water to make sure that they tasted the real broccoli cracker taste, which had a different concentration. The broccoli cracker's sensory properties, which are colour, texture, taste, and aroma, were evaluated. The attributes of broccoli crackers were evaluated using the 7 sensory scores as in Table 3.2. The data obtained were analyzed using the Statistical Package for the Social Science (SPSS) by using the One-Way-Analysis of Variance (ANOVA).

Table 3.2 Hedonic scale rating for sensory evaluation

Likeness	Sensory score
Like very much	1
Like moderately	2
Like	3
Neither like nor dislike	4
Dislike	5
Dislike moderately	6
Dislike very much	7

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Physical Properties

4.1.1 Colour Analysis

Food appearance and colour are the main factors judged before a customer-purchased a product. Commonly, nice food colour gives a good impression to the consumers where consumers tend to think that the nice food colour means high food products quality. In comparison to the other senses, the vision has the advantage of recording an observer's impression of an object's appearance (Piggott, 1988). Small colour distinctions, such as the colour discrimination threshold, have been extensively investigated because the colour industries are primarily concerned with these variances. In the area of colour reproduction and industrial design involving colour image processing, however, a typical colour difference could be greater than 10 CIELAB ΔE units (Xu, H. et al., 2001). The food colour is one of an attribute that important in increasing the consumers' preference when consuming foods. The values of L*, a*, and b* were based on the CIELAB colour space. L* indicates the lightness, a* indicates redness, and b* indicates yellowness. This colour attribute was tested using the Konica Minolta Chroma Meter.

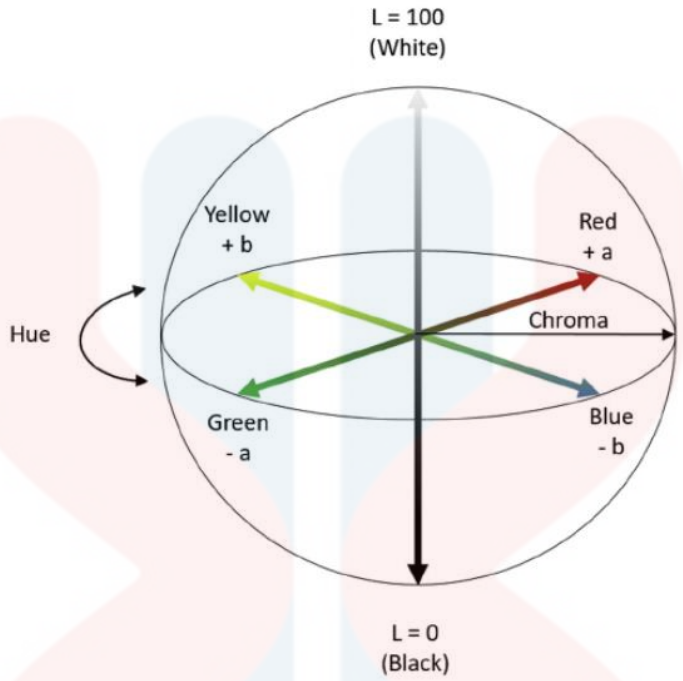


Figure 4.1 The CIELAB colour space diagram (Source: Del Bino, et al., 2020).

Figure 4.1 shows the CIELAB colour system, often known as the CIE L* a* b* colour system, provides the quantitative relationship between colours on three axes: L*value denotes lightness, and the a* and b* is the colour space coordinates. L* is depicted on a vertical axis with values ranging from 0 (black) to 100 (white) on the colour space diagram. Where +a* denote the red value and -a* denote the green value. the a* value indicates the red-green component of a colour. On the b* axis, +b* indicate the yellow value and -b* indicate the blue value (Del Bino, 2020). Figure 4.2, Figure 4.3 and Figure 4.4 below shows the values for colour attributes of broccoli cracker with different broccoli concentration; BC0 (broccoli cracker with 0% of broccoli concentration), BC2 (broccoli cracker with 2% of broccoli concentration), BC4 (broccoli cracker with 4% of broccoli concentration), BC6 (broccoli cracker with 6% of broccoli concentration), and BC8 (broccoli cracker with 8% of broccoli concentration).

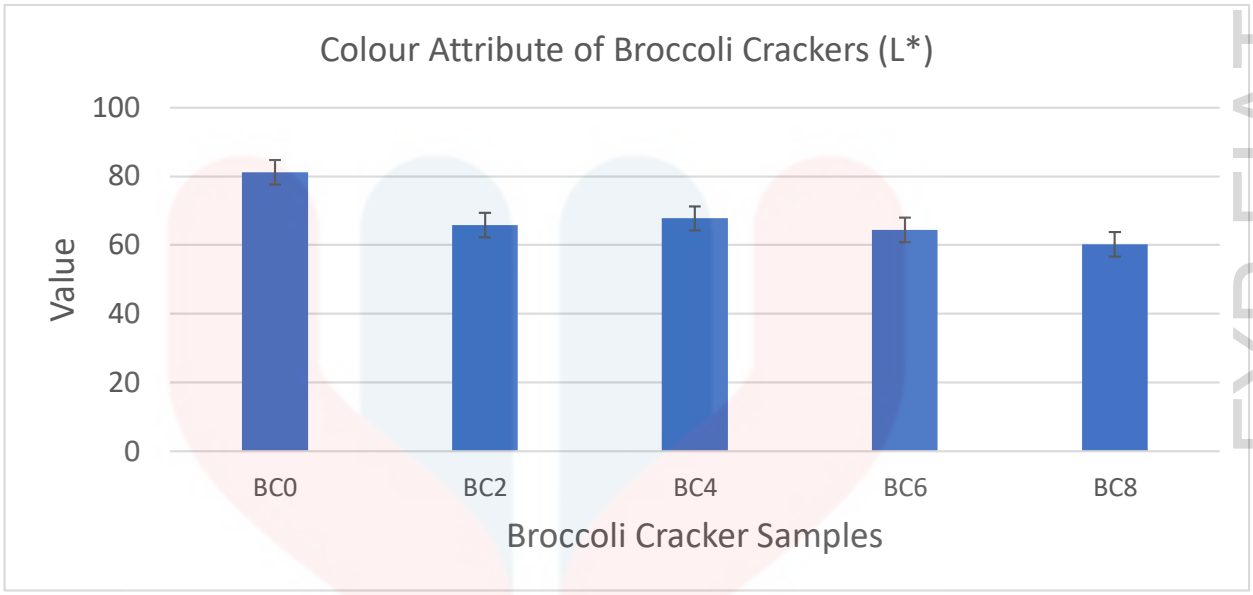


Figure 4.2 Value for lightness (L*) of broccoli cracker with different broccoli concentration

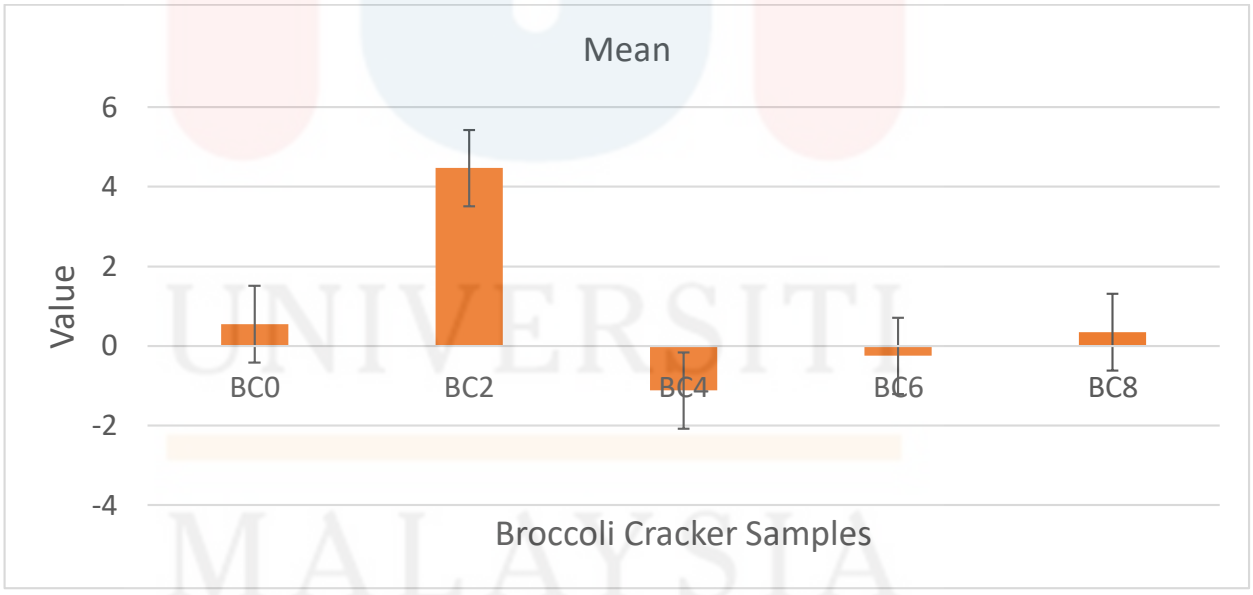


Figure 4.3 Value for redness (a*) of broccoli cracker with different broccoli concentration

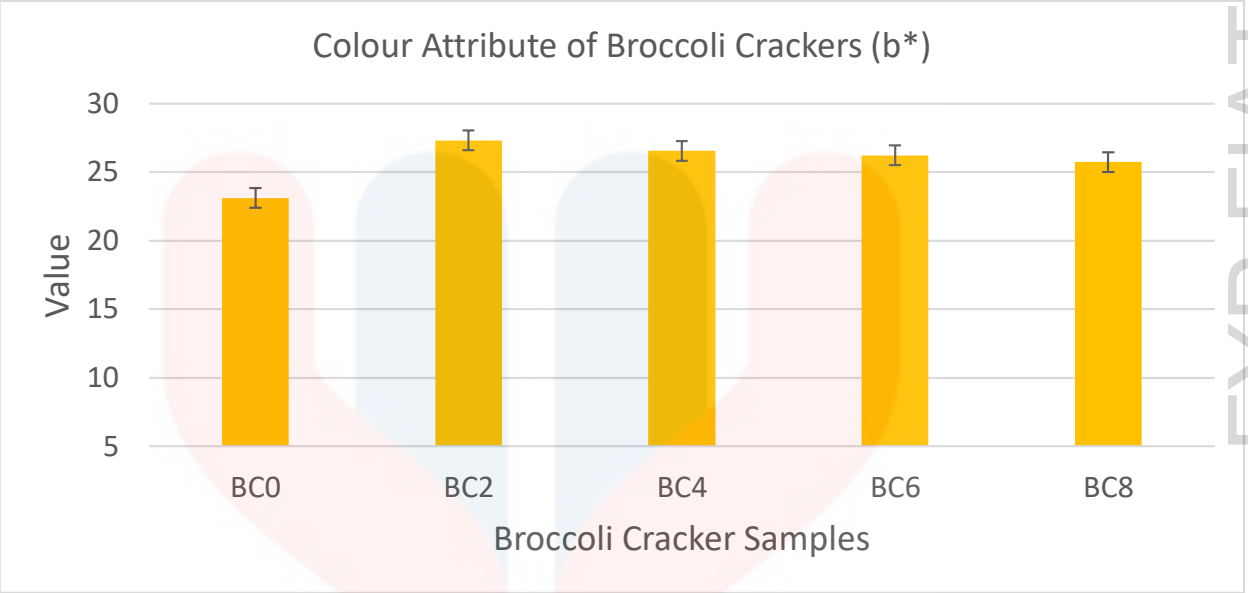


Figure 4.4 Value for yellowness (b*) of broccoli cracker with different broccoli concentration

Based on Figure 4.2, the value for lightness (L*) of broccoli cracker with different broccoli concentration, the highest value of lightness recorded was ΔL^* = 81.1567 from the broccoli cracker with 0% of broccoli concentration and the lowest value of lightness recorded was ΔL^* = 60.1767 from the broccoli cracker with 8% of broccoli concentration. For broccoli cracker with 2%, 4% and 6% of broccoli concentration, the lightness value was ΔL^* = 65.8167, ΔL^* = 67.76 and ΔL^* = 64.41, respectively.

Figure 4.3, the value for redness (a*) of broccoli cracker with different broccoli concentration, shows the redness value of broccoli cracker. The highest redness value recorded was Δa^* = 0.5467 from the broccoli cracker with 0% of broccoli concentration and the lowest value is Δa^* = -0.25 from broccoli cracker with 6% of broccoli concentration. For broccoli cracker with 2%, 4% and 8% of broccoli concentration, the redness value recorded was Δa^* = 4.47, Δa^* = -1.12 and Δa^* = 0.3433, respectively.

Lastly, Figure 4.4, the value for yellowness (b*) of broccoli cracker with different broccoli concentration, shows the yellowness value of broccoli cracker. The highest yellowness value recorded was Δb^* = 27.3167 from the broccoli cracker with 2% of broccoli concentration and the lowest value is Δb^* = 23.1033 from broccoli cracker with 0% of broccoli concentration. For broccoli cracker with 4%, 6% and 8% of broccoli concentration, the redness value recorded was Δb^* = 26.56, Δb^* = 26.22 and Δb^* = 25.7433, respectively. Based on the results of lightness, redness and yellowness above, broccoli crackers with 6% of broccoli concentration were the most acceptable because its color were nice and attractive.

4.1.2 Texture Profile Analysis

In the early 1960's, at General Foods' Technical Center, a food scientist, Dr. Alina Surmacka Szczesniak, the principal at General Foods, and founding editor of Journal of Texture Studies, invented the original Texture Profile Analysis (TPA) parameters as part of the sensory work. Texture Profile Analysis (TPA) is a commonly used method for testing solid and semisolid products (Rosenthal, 2010). TPA involves in determining the physical properties such as adhesiveness, hardness, fracturability, gumminess and chewiness. In this research, the two analyses that had done were hardness and the fracturability. The texture attributes were analyzed using the Texture Analyzer (Brookfield, CT3, USA).

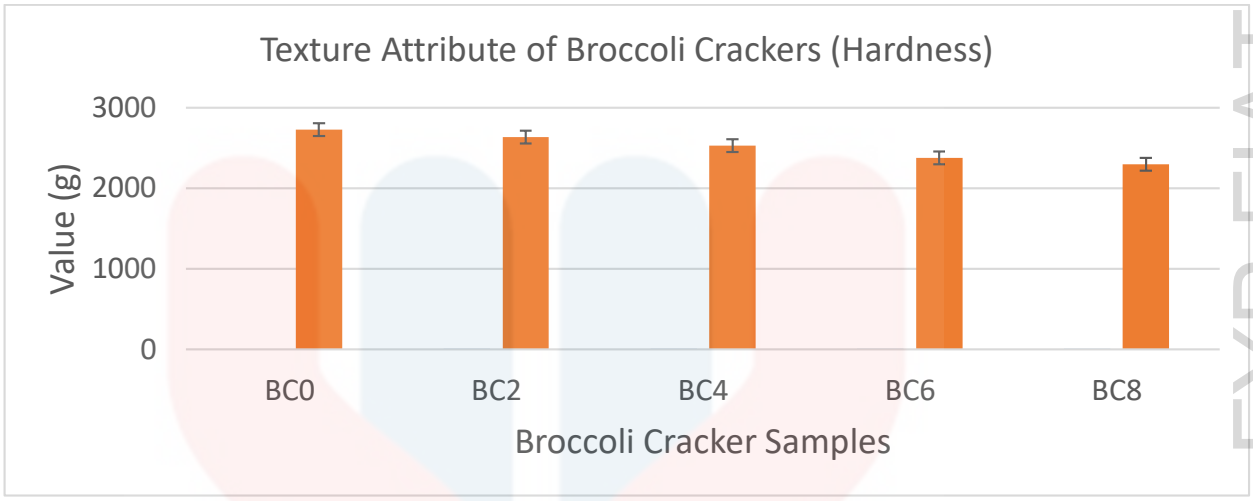


Figure 4.5 Value of broccoli crackers' texture attribute (hardness) of broccoli cracker with different broccoli concentration

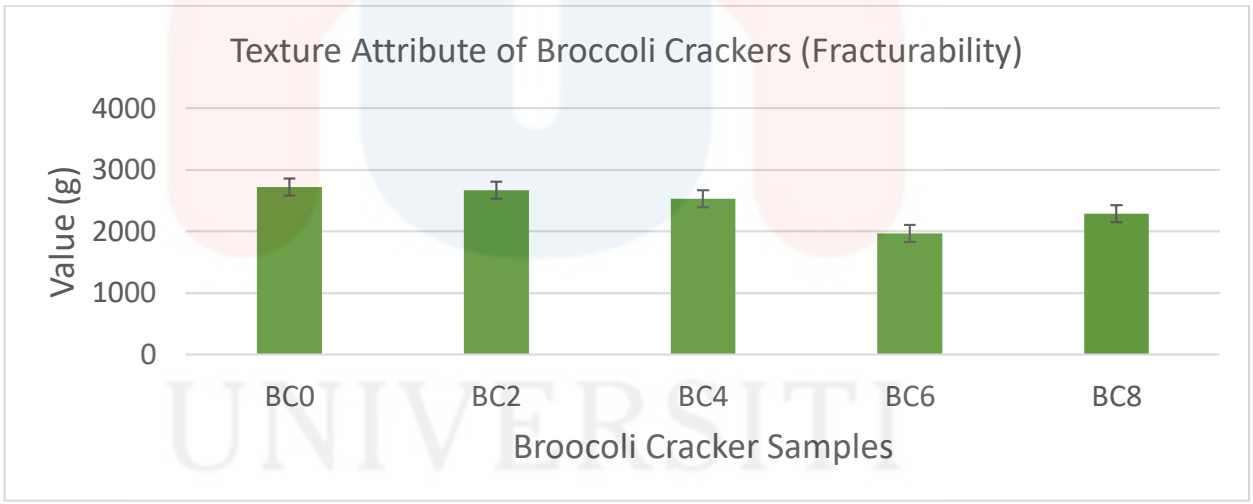


Figure 4.6 Value of broccoli crackers' texture attribute (fracturability) of broccoli cracker with different broccoli concentration

The hardness value of the crackers was recorded based on the peak force required to break it (Adeola & Ohizua, 2018). The hardness value represents the peak force that occurs in the first compression. Hardness value does not have to take place only at the

point of greatest compression, though it did occur in most products. Based on Figure 4.5, the value of broccoli crackers' texture attribute (hardness) of broccoli cracker with different broccoli concentration, the highest value recorded was 2723.667 g from broccoli cracker with 0% broccoli concentration. While, the lowest value recorded was 2294 g from broccoli cracker with 8% of broccoli concentration. For broccoli cracker with 2%, 4% and 6% of broccoli concentration, the hardness value recorded was 2631.5 g, 2526.667 g and 2376.833 g, respectively.

On the other hand, fracturability assesses a product's ability to recover its original status or form (Adeola & Ohizua, 2018). When a product fractures, the fracturability value is the significant peak that happened during the first compression of the probe to the product. Based on Figure 4.6, the value of broccoli crackers' texture attribute (fracturability) of broccoli cracker with different broccoli concentration, the highest value recorded was 2723.667 g from broccoli cracker with 0% of broccoli concentration. While, the lowest value recorded was 1969.333 g from broccoli cracker with 6% of broccoli concentration. For broccoli cracker with 2%, 4% and 8% of broccoli concentration, the hardness value recorded were 2669 g, 2526.667 g and 2285.333 g, respectively.

4.2 Proximate Analysis

In this research, the proximate analysis was the protein content, fat content, ash content, moisture content and carbohydrate content. All the proximate analysis was done with the broccoli cracker powder which had different broccoli concentrations of 0%, 2%, 4%, 6% and 8%.

4.2.1 Protein Content

This experiment took 1 g of broccoli powder for each concentration. However, to get a more accurate result, each concentration was tested three times, which means each concentration of broccoli cracker powder prepared was 3 g in total.

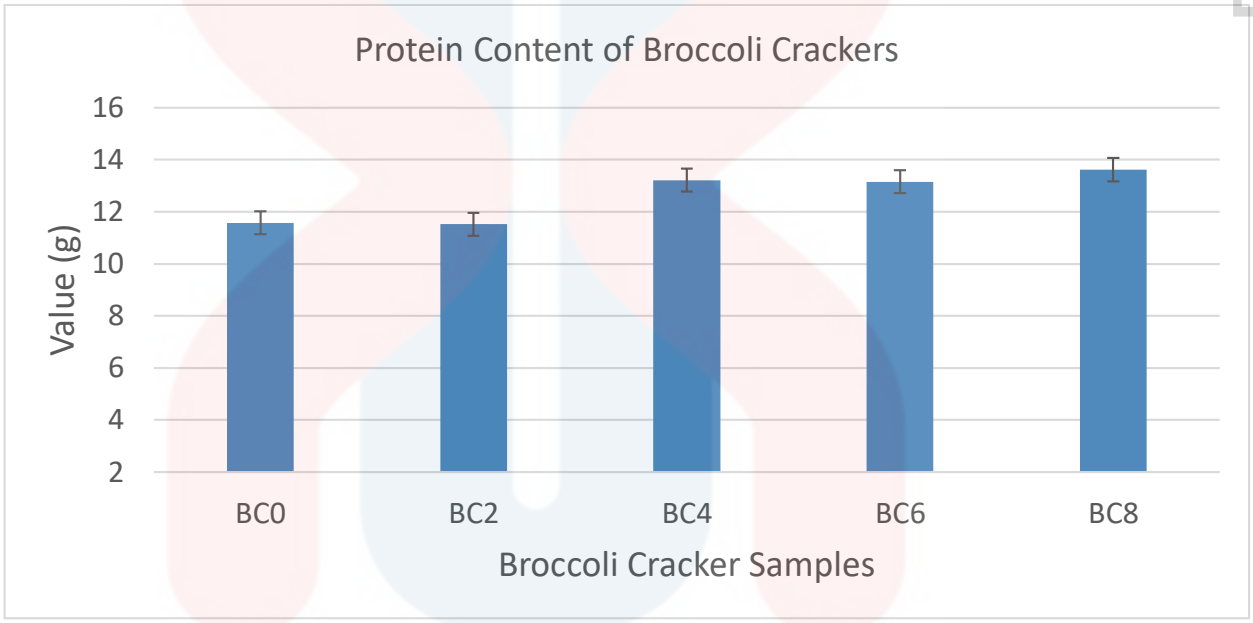


Figure 4.7 Value of the protein content of broccoli cracker

Based on Figure 4.7, the value of the protein content of broccoli cracker, the highest value of protein content was 13.6164 g ± 1.0595 g from the broccoli cracker with 8% of broccoli concentration and the lowest value of protein content recorded was 11.5111 g ± 1.2517 g from the broccoli cracker with 2% of broccoli concentration. The second highest value recorded was 13.2096 g ± 0.6193 g from the broccoli cracker with 4% of broccoli concentration, followed by 13.1503 g ± 0.7847 g from the broccoli cracker with 6% of broccoli concentration. Lastly, the value that has been recorded was 11.5747 g ± 1.6485 g from the broccoli cracker with 0% of broccoli concentration.

The type and quality of protein we take are essential to our health and well-being. Protein in the diet can provide energy and proper protein intake is an important nutritional way to reduce the risk of illnesses such as sarcopenia in an aging global population. Protein is recognized as a nutritional factor that can reduce or even prevent muscle strength and mass loss. Muscle strength and mass both decrease over time in our 50s, with a 30–50% loss of muscle mass commonly encountered between the ages of 40–80 (Hayes, 2020).

Many methods are used in the food industry to analyze protein content in foods, including the Kjeldahl, Lowry, Bradford, and total amino acid content methods. The correct determination of protein content in foods is important because it often determines the economic value of the food product. In this research Kjeldahl method was used. The Kjeldahl method is where the food was digested with a strong acid, releasing nitrogen, then measured using a titration technique. The advantage of using the Kjeldahl method was that it was recognized as the global standard method, making it easy to make a compare of the results with other laboratories. However, the disadvantage was because of the use of the standard nitrogen correction factor 6.25, and it does not measure true protein, which can result in the overestimation of protein (Sáez-Plaza et al., 2013).

4.2.2 Fat Content

This experiment took 1.5 g of broccoli powder for each concentration. However, to get a more accurate result, each concentration was tested three times, which means each concentration of broccoli cracker powder prepared was 4.5 g in total.

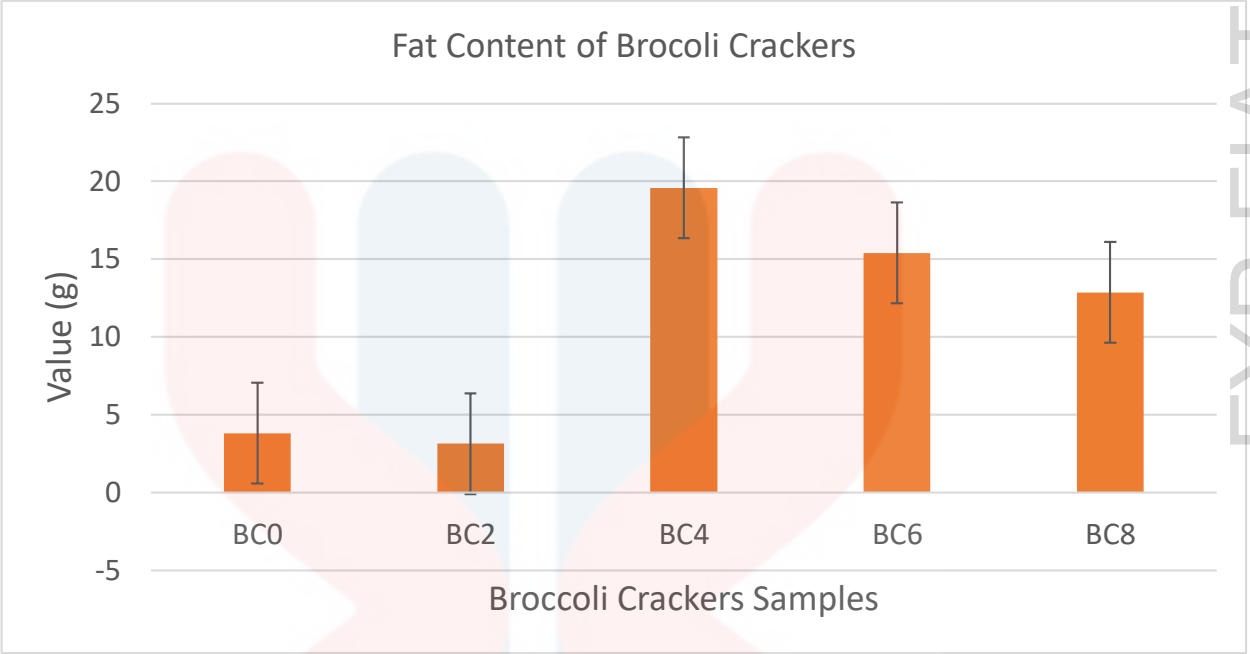


Figure 4.8 Value of the fat content of broccoli cracker

Based on Figure 4.8, the value of the fat content of broccoli cracker, the highest value of fat content was 19.5807 g ± 2.4298 g from the broccoli cracker with 4% of broccoli concentration. The lowest value of fat content recorded was 3.1513 g ± 2.1035 g from the broccoli cracker with 2% of broccoli concentration. The second highest value recorded was 15.3955 g ± 6.8149 g from the broccoli cracker with 6% of broccoli concentration, followed by 12.859 g ± 4.3938 g from the broccoli cracker with 8% of broccoli concentration. Lastly, the value that has been recorded was 3.8091 g ± 0.6993 g from the broccoli cracker with 0% of broccoli concentration.

One of the most common analysis conducted in a food laboratory is determining the fat content of food. The fat content of food is one of the most commonly used values in food databases, and it is typically used to assess the energy content of food. Fat acts as a shortening agent which referred to its ability to weaken and lubricate the food component structure to get food product with preferred textural properties (Mamat & Hill, 2012). Fats lubricate the mixing process and inhibit the production of a gluten network in

the dough. In the absence of shortening, the water or sugar solution would react with the flour protein to form cohesive and extensible gluten; however, when shortening is present, the fats encircle the proteins and starch granules, separating them from the water and breaking the cohesiveness of protein and starch structure. Fat is a key ingredient that contributes to the tenderness of crackers while also preserving the quality and texture of the crackers (Mamat & Hill, 2012).

4.2.3 Ash Content

This experiment took 1 g of broccoli powder for each concentration. However, to get a more accurate result, each concentration was tested three times, which means each concentration of broccoli cracker powder prepared was 3 g in total.

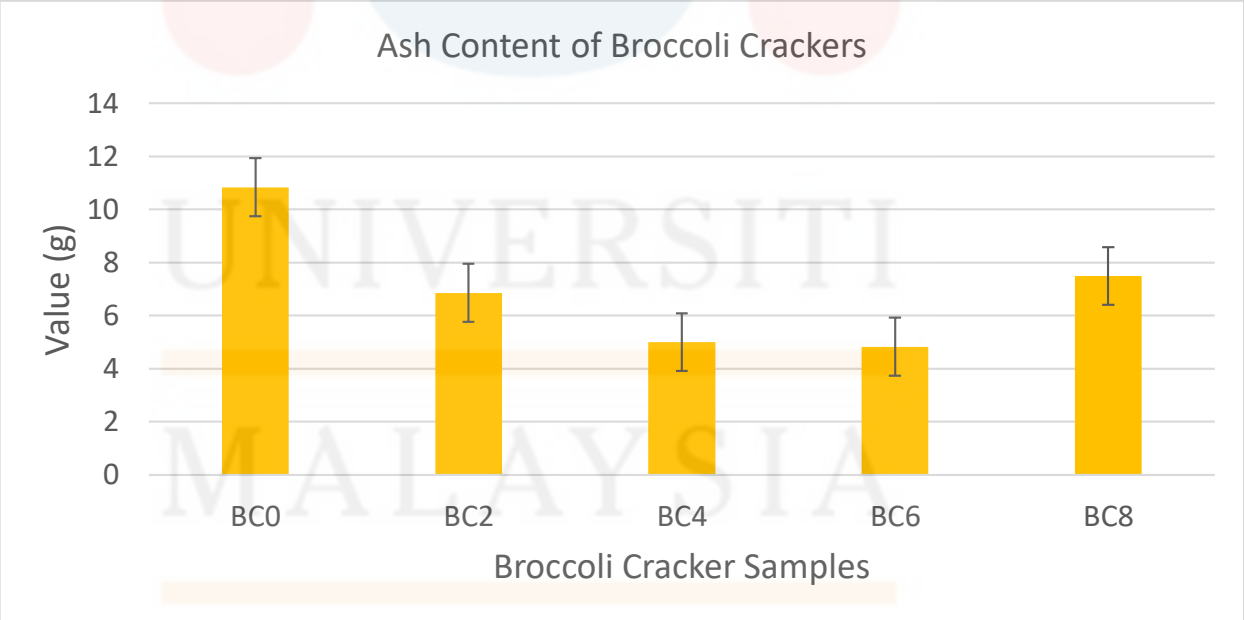


Figure 4.9 Value of the ash content of broccoli cracker

Based on Figure 4.9, the value of the ash content of broccoli cracker, the highest value of ash content was 10.8416 g ± 1.1157 g from the broccoli cracker with 0% of broccoli concentration and the lowest value of ash content recorded was 4.8274 g ± 1.7016 g from the broccoli cracker with 6% of broccoli concentration. The second highest value recorded was 7.4916 g ± 0.8371 g from the broccoli cracker with 8% of broccoli concentration, followed by 6.8603 g ± 0.2483 g from the broccoli cracker with 2% of broccoli concentration and lastly, the value that has been recorded was 4.9971 g ± 1.2428 g from the broccoli cracker with 4% of broccoli concentration.

The inorganic residue left after the emission or complete oxidation of organic matter in a food sample is referred to as ash. The minerals present in the food sample form the majority of the inorganic residue. The ash content is determined as part of the proximate analysis for nutritional evaluation. Ashing is also the first step in preparing a sample for specific elemental analysis. Dry ashing and wet ashing are the two most common types of ashing procedures. Dry ashing is the process of heating food at high temperatures (500–600 °C) in a furnace. Water and volatiles will evaporate, and organic matter will burn and convert to CO_2 and N_2 oxide in the presence of oxygen (Ismail, 2017). However, for broccoli, 400˚C was a suitable temperature. Meanwhile, wet ashing works by oxidising organic matter with acids or / and oxidising agents.

4.2.4 Moisture Content

This experiment took 1 g of broccoli powder for each concentration. However, to get a more accurate result, each concentration was tested three times, which means each concentration of broccoli cracker powder prepared was 3 g in total.

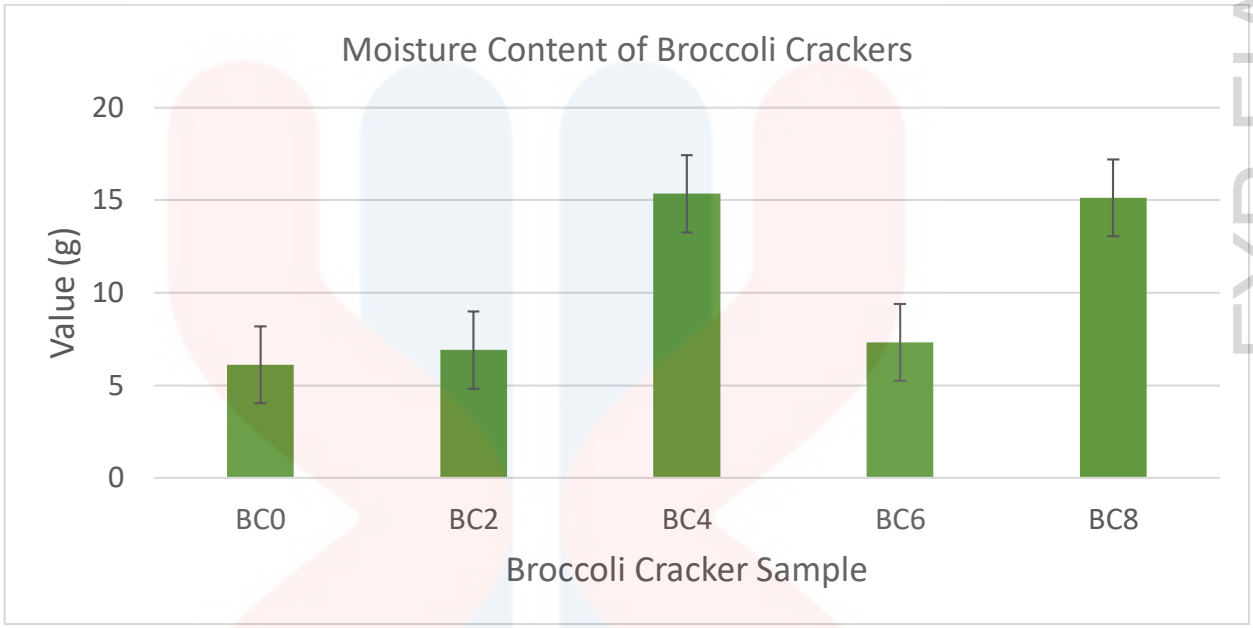


Figure 4.10 Value of the moisture content of broccoli cracker

Based on Figure 4.10, the value of the moisture content of broccoli cracker, the highest value of moisture content was 15.3411 g ± 19.776 g from the broccoli cracker with 4% of broccoli concentration and the lowest value of the moisture content recorded was 6.1059 g ± 0.1548 g from the broccoli cracker with 0% of broccoli concentration. The second highest value recorded was 15.1239 g ± 13.6741 g from the broccoli cracker with 8% of broccoli concentration, followed by 7.3227 g ± 4.2695 g from the broccoli cracker with 6% of broccoli concentration. Lastly, the value that has been recorded was 6.9074 g ± 1.5165 g from the broccoli cracker with 2% of broccoli concentration.

4.2.5 Carbohydrate Content

Carbohydrate content was calculated by subtracting 100% to the sum of percentage of protein content, percentage of fat content, percentage of ash content and the percentage of moisture content.

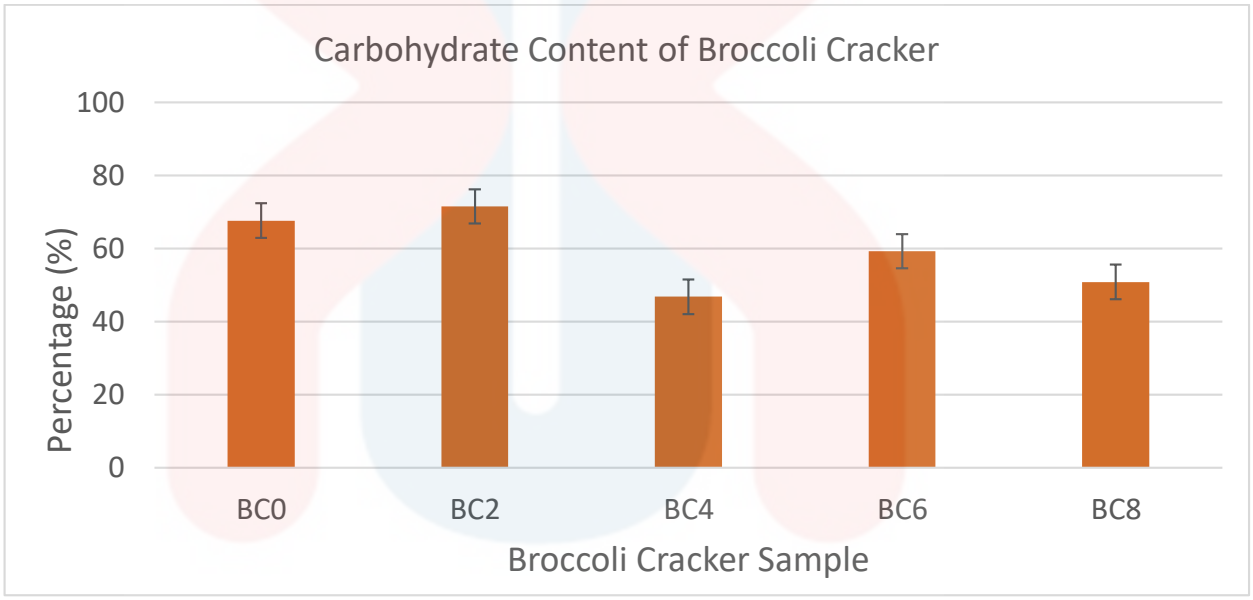


Figure 4.11 Percentage of the carbohydrate content of broccoli cracker

Based on Figure 4.11, the highest percentage of carbohydrate content was 71.56% from the broccoli cracker with 2% of broccoli concentration and the lowest percentage of carbohydrate content recorded was 46.87% from the broccoli cracker with 4% of broccoli concentration. The second highest percentage recorded was 67.67% from the broccoli cracker with 0% of broccoli concentration, followed by 59.30% from the broccoli cracker with 6% of broccoli concentration and lastly, the percentage that has been recorded was 50.91% from the broccoli cracker with 8% of broccoli concentration.

4.4 Overall acceptance of Broccoli Cracker

Table 4.1 shows the score values in mean and standard deviation from sensory evaluation of five attributes: colour, texture, taste, aroma and overall acceptance of broccoli cracker.

Table 4.1 The score values in mean and standard deviation from sensory evaluation of five attributes of broccoli crackers.

	Attributes				
Broccoli concentration (%)	Colour	Texture	Taste	Aroma	Overall acceptance
0%	2.71 ± 1.888	3.77 ± 1.864	3.20 ± 1.677	3.06 ± 1.552	3.26 ± 1.686
2%	2.71 ± 1.601	3.74 ± 1.771	3.00 ± 1.680	3.03 ± 1.723	3.11 ± 1.771
4%	2.83 ± 1.671	3.46 ± 2.049	3.20 ± 1.907	3.34 ± 1.781	3.20 ± 1.922
6%	2.83 ± 1.723	4.09 ± 1.976	3.74 ± 2.020	3.40 ± 1.752	3.86 ± 2.002
8%	3.40 ± 1.928	4.40 ± 1.958	4.00 ± 1.955	3.80 ± 1.937	4.06 ± 1.862

Based on Table 4.1, the score values in mean and standard deviation from sensory evaluation of five attributes of broccoli crackers, the lowest mean of colour attribute of broccoli crackers is from the broccoli crackers with 0% and 2% which was 2.71 ± 1.888 and 2.71 ± 1.601 respectively. For the texture attribute, the lowest mean of the broccoli crackers was from the broccoli crackers with 4% of broccoli concentration (3.46 ± 2.049). Besides, for taste attribute, the lowest mean of the broccoli crackers was from the broccoli crackers with 2% of broccoli concentration (3.00 ± 1.680) and for the aroma attribute, the lowest mean of the broccoli crackers also from the broccoli crackers with 2% of broccoli concentration (3.03 ± 1.723). The lowest mean for overall acceptance was from the broccoli crackers with 2% broccoli concentration (3.11 ± 1.771).

Meanwhile, the highest mean for all attributes obtained was broccoli crackers with 8% of broccoli concentration. The mean of colour attribute that has been recorded was 3.40 ± 1.928, the mean of texture attribute was 4.40 ± 1.958, the mean of taste attribute was 4.00 ± 1.955, the mean of aroma attribute was 3.80 ± 1.937 and the mean of overall acceptance was 4.06 ± 1.862. This shows that the preferred broccoli crackers from most respondents were broccoli crackers with 8% of broccoli concentration.

After surveying the consumers' acceptability towards the cracker made from broccoli through a google form, which was from 35 random respondents, the results were obtained. The results of overall acceptance obtained from the sensory evaluation were then analyzed using the Statistical Package for the Social Science (SPSS) by using the One-Way-Analysis of Variance (ANOVA). The highest mean recorded of the overall acceptance from the respondents is from the broccoli cracker with 8% of broccoli concentration (4.06 ± 1.862). Then, it followed by the broccoli cracker with 6% of broccoli concentration (3.86 ± 2.002), broccoli cracker with 0% of broccoli concentration

(3.26 ± 1.686), broccoli cracker with 4% of broccoli concentration (3.20 ± 1.922) and the lowest mean recorded of the overall acceptance from the respondents is from the broccoli cracker with 2% of broccoli concentration (3.11 ± 1.711). This result shows that the broccoli cracker with 2% of broccoli concentration was the most preferred with the lowest mean score according to the hedonic scale rating for sensory evaluation (like extremely; score 1, dislike extremely; score 7)

Table 4.2 ANOVA results for the overall acceptance of broccoli crackers

ANOVA

Source of Variation	Sum of square	df	Mean square	F	P-value
Between Groups	25.749	4	6.437	1.900	0.113
Within Groups	576.000	170	3.388		
Total	601.749	174			

Based on Table 4.2, the P-value was 0.113, more than the significant value (0.05). When P-value was higher than 0.05, thus, there was no significant difference, which means the null hypothesis is accepted. Therefore, the post hoc test was not be conducted.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

In conclusion, the use of different concentrations of broccoli in the cracker's dough which was 0%, 2%, 4%, 6% and 8% does affect the protein, fat, ash, moisture and carbohydrate content of broccoli cracker. However, the results showed an unstable pattern which might cause by the miscalculation during the weighing process. This research also shows that different concentrations of broccoli have different colors, which was tested using the Konica Minolta Chroma Meter. Besides, after the texture profile analysis was conducted using the Texture Analyzer (Brookfield, CT3, USA), the results showed that the broccoli cracker with different broccoli concentrations has a different texture. The hardness and fracturability results from texture analysis showed a decreasing pattern with increasing broccoli concentration in broccoli crackers. The overall acceptance result from the sensory evaluation conducted by 35 students was from the broccoli cracker with 2% of broccoli concentration. It is recommended to research on crackers using other types of vegetables such as spinach, carrot, pepper and radish. Besides, another analysis also can be done such as pH and energy content. Lastly, it is suggested to get more respondents for the sensory evaluation.

REFERENCES

Adeola, A. A., & Ohizua, E. R. (2018). Physical, chemical, and sensory properties of biscuits prepared from flour blends of unripe cooking banana, Pigeon Pea, and sweet potato. *Food Science & Nutrition*, *6*(3), 532–540. https://doi.org/10.1002/fsn3.590

Blamire, J. (2003). Kjeldahl Method. SD-Kjeldahl Method. http://www.brooklyn.cuny.edu/bc/ahp/SDKC/Chem/SD_KjeldahlMethod.html

Britannica, T. Editors of Encyclopaedia (2020). Broccoli. Encyclopedia Britannica: https://www.britannica.com/plant/broccoli

Food and Agriculture Organization of the United Nations. (2020). Broccoli (and cauliflower) production in 2019, Crops/Regions/World list/ Production Quantity (pick list): https://www.fao.org/faostat/en/#data/QC

Del Bino, S., E. B., Feig, J. L., Chien, A. L., & Ly, B. C. (2020). Research techniques made simple: Cutaneous colorimetry: A reliable technique for objective skin color measurement. *Journal of Investigative Dermatology*, *140*(1), 3–12. https://doi.org/10.1016/j.jid.2019.11.003

Food Research International (2009). Sensory Properties. Sensory Properties - an overview | ScienceDirect Topics: https://www.sciencedirect.com/topics/food-science/sensory-properties

Gavin, J., says, B. G., & Geils, B. (2019). *Types of Broccoli*. Jessica Gavin Culinary Scientist. https://www.jessicagavin.com/types-of-broccoli

Hayes, M. (2020). Measuring protein content in food: An overview of methods. *Foods*, *9*(10), 1340. https://doi.org/10.3390/foods9101340

Hill, A. (2018). Top 14 Health Benefits of Broccoli: https://www.healthline.com/nutrition/benefits-of-broccoli

Ismail, B. P. (2017). Ash content determination. *Food Analysis Laboratory Manual*, 117–119. https://doi.org/10.1007/978-3-319-44127-6_11

Mahn, A., & Reyes, A. (2012). An overview of health-promoting compounds of broccoli (brassica oleraceavar. italica) and the effect of processing. *Food Science and Technology International*, *18*(6), 503-514. doi:10.1177/1082013211433073

Mamat, H., & Hill, S. E. (2012). Effect of fat types on the structural and textural properties of dough and semi-sweet biscuit. *Journal of Food Science and Technology*, *51*(9), 1998–2005. https://doi.org/10.1007/s13197-012-0708-x

Piggott, J. R. (1988). Sensory analysis of foods. *Department of Bioscience and Biotechnology, Food Science Division*, University of Strathelyde: Glasgow, United Kingdom

Ravikumar, C. (2015). Therapeutic Potential of Brassica oleracea (Broccoli) - A Review. *Therapeutic Potential of Brassica Oleracea (Broccoli) - A Review*, *7*(2), 009-010.

Rosenthal, A. J. (2010). Texture profile analysis - how important are the parameters? *Journal of Texture Studies*, *41*(5), 672–684. https://doi.org/10.1111/j.1745-4603.2010.00248.x

Sáez-Plaza, P., Navas, M. J., Wybraniec, S., Michałowski, T., & Asuero, A. G. (2013). An overview of the Kjeldahl method of nitrogen determination. part II. sample preparation, working scale, instrumental finish, and Quality Control. *Critical Reviews in Analytical Chemistry*, *43*(4), 224–272. https://doi.org/10.1080/10408347.2012.751787

National Museum of American History (n.d.). Soxhlet's extraction tube: https://americanhistory.si.edu/collections/search/object/nmah_940

Ware, M. (2018). Vitamin k: Health benefits, daily intake, and sources: https://www.medicalnewstoday.com/articles/219867

Xu, H., Yaguchi, H., & Shioiri, S. (2001). Testing cielab-based color-difference formulae using large color differences. *Optical Review*, *8*(6), 487–494. https://doi.org/10.1007/bf02931740

Zelman, K. (2020). Vitamin c benefits, sources, supplements, & more: https://www.webmd.com/diet/features/the-benefits-of-vitamin-c

APPENDIX A

Table A Cost for production of broccoli crackers

ITEMS	QUANTITY	PRICE
All-purpose flour	3 kg	RM 8.00
Baking powder	120 g	RM 1.00
Salt	500 g	RM 2.00
Butter	1 kg	RM 3.00
Broccoli	2 kg	RM 5.00

APPENDIX B

Figure B.1 Broccoli used in broccoli cracker production

Figure B.2 Gerhardt machine

Figure B.3 Soxtec machine

Figure B.4 Furnace used for ash content analysis

Figure B.5 Inside the furnace

Figure B.6 Oven used for moisture content analysis

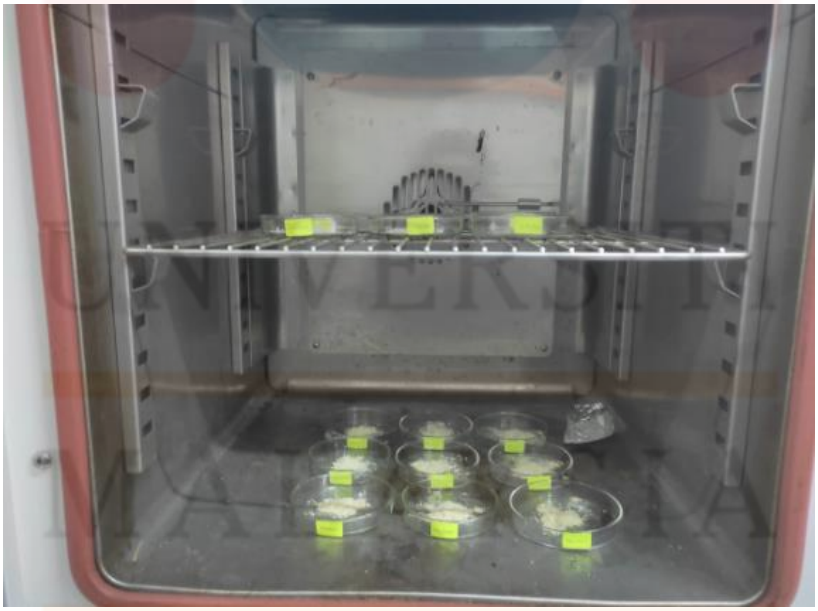


Figure B.7 Inside the oven

Figure B.8 Texture profile analyzer (Brookfield**)**

Figure B.9 Packaging for sensory evaluation

APPENDIX C

Table C.1 Protein content of broccoli cracker

Broccoli cracker (code)	Broccoli cracker (%)	Sample weight (g)	HCl (ml)	N (%)	Protein (%)
001	0	1.0009 ± 0.0002	13.2333 ± 1.88237	1.85196 ± 0.26376	11.5747 ± 1.6485
002	2	1.00093 ± 0.00042	13.1667 ± 1.43643	1.84248 ± 0.20027	11.5155 ± 1.25166
003	4	1.00073 ± 0.00061	15.1 ± 0.7	2.11354 ± 0.09908	13.2096 ± 0.611928
004	6	1.0008 ± 0.00066	15.0333 ± 0.89629	2.10404 ± 0.12555	13.1503 ± 0.78466
005	8	1.00083 ± 0.00021	15.5667 ± 1.20968	2.17862 ± 0.16952	13.6164 ± 1.0595

Table C.2 Fat content of broccoli cracker

Broccoli cracker (code)	Broccoli cracker (%)	Sample weight (g)	Aluminium cup + fat (g)	Fat (g)	Fat (%)
001	0	1.50073 ± 0.00042	40.6768 ± 0.85123	0.05717 ± 0.01051	3.80912 ± 0.69933
002	2	1.5011 ± 0.00044	40.7941 ± 0.22781	0.0473 ± 0.03156	3.15128 ± 2.10348
003	4	1.5018 ± 0.0015	40.7565 ± 0.77487	0.29407 ± 0.03654	19.5807 ± 2.42975
004	6	1.50167 ± 0.0005	41.0261 ± 0.41142	0.23117 ± 0.10226	15.3955 ± 6.81486
005	8	1.50273 ± 0.00292	41.4421 ± 0.37502	0.19323 ± 0.06594	12.859 ± 4.39377

Table C.3 Ash content of broccoli cracker

Broccoli cracker (code)	Broccoli cracker (%)	Sample weight (g)	Crucible + ash (g)	Ash (g)	Ash (%)
001	0	1.0076 ± 0.00439	34.0618 ± 2.97885	0.1092 ± 0.01115	10.8416 ± 1.1157
002	2	1.0139 ± 0.01201	35.7144 ± 3.05906	0.0696 ± 0.00304	6.8603 ± 0.24827
003	4	1.01934 ± 0.01356	38.4537 ± 1.35495	0.0534 ± 0.01514	4.9971 ± 1.24275
004	6	1.0047 ± 0.00196	32.68197 ± 1.624022	0.0485 ± 0.0171	4.8274 ± 1.70157
005	8	1.0013 ± 0.00095	37.277 ± 2.211796	0.0772 ± 0.0053	7.4916 ± 0.83709

Table C.4 Moisture content of broccoli cracker

Broccoli cracker (code)	Broccoli cracker (%)	Sample weight (g)	Dried weight (g)	Moisture (%)
001	0	1.00453 ± 0.00309	0.9432 ± 0.00406	6.10585 ± 0.15477

002	2	1.0034 ± 0.00243	0.93407 ± 0.01301	6.90742 ± 1.51653
003	4	1.01997 ± 0.00414	0.86403 ± 0.20471	15.3411 ± 19.776
004	6	1.0006 ± 0.00104	0.9273 ± 0.041179	7.32267 ± 4.26946
005	8	1.0114 ± 0.003	0.85863 ± 0.14001	15.1239 ± 13.6741

Broccoli cracker (code)	Broccoli cracker (%)	Protein (%)	Fat (%)	Ash (%)	Moisture (%)	Carbohydrate (%)
001	0	11.57472 ± 1.64850	3.80913 ± 0.69933	10.84163 ± 1.115698	6.10585 ± 0.15477	67.67
002	2	11.51553 ± 1.25166	3.15128 ± 2.10348	6.86027 ± 0.24827	6.90742 ± 1.51653	71.56
003	4	13.20963 ± 0.61928	19.58073 ± 2.42975	4.9971 ± 1.24275	15.34113 ± 19.77603	46.87

004	6	13.15023 ± 0.784695	15.39547 ± 6.814864	4.8274 ± 1.701571	7.322669 ± 4.269459	59.3
005	8	13.61627 ± 1.059505	12.85897 ± 4.393773	7.491567 ± 0.837085	15.1239 ± 13.67409	50.91

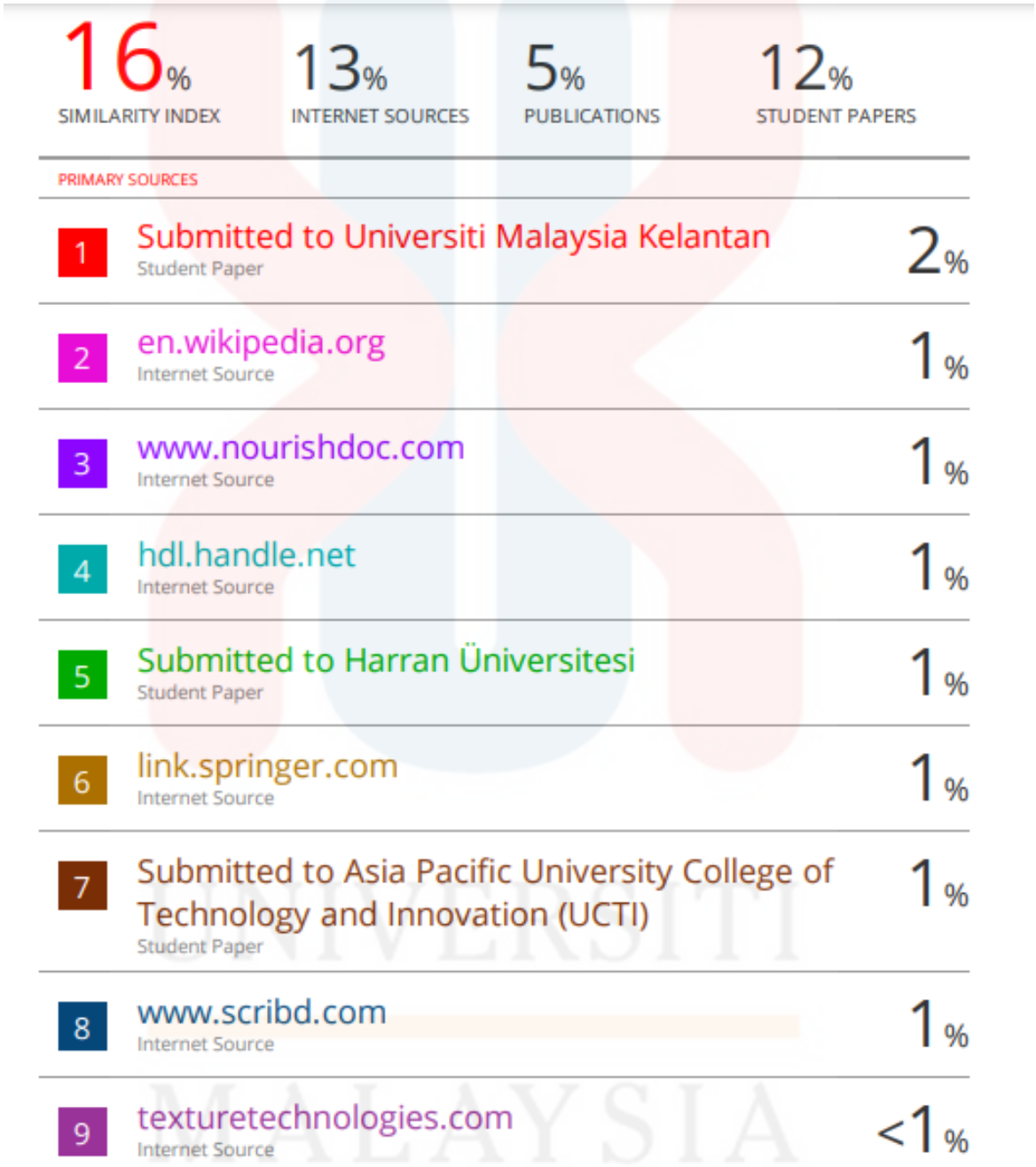
Table C.5 Carbohydrate content of broccoli cracker

Table C.6 Mean of overall acceptance for each broccoli concentration

Descriptive

Concentration	N	Mean	SD	SE	95% Confidence Interval for Mean		Minimum	Maximum
					Lower bound	Upper bound		
0	35	3.26	1.686	.285	2.68	3.84	1	7
2	35	3.11	1.711	.289	2.53	3.70	1	7
4	35	3.20	1.922	.325	2.54	3.86	1	7
6	35	3.86	2.002	.338	3.17	4.54	1	7
8	35	4.06	1.862	.315	3.42	4.70	1	7

Total	175	3.50	1.860	.141	3.22	3.77	1	7



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