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Influence of Breadfruit Flour on Physicochemical Properties of The Muffins

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DECLARATION

I admit that this work is my own work except for citations and summaries that I have each explained.

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Influence of breadfruit flour on physicochemical properties of the muffins

ABSTRACT

Breadfruit contains a considerable amount of starch and other nutrients. The research was conducted to determine the physicochemical and nutritional properties of muffin incorporated with breadfruit flour at 25 % (F2), 50 % (F3), 75 % (F4), and 100 % (F5). The muffin without breadfruit flour served as a control muffin (F1). The color properties that were lightness (L*), redness (a*), and yellowness (b*) of breadfruit flour and muffin were determined using a Chroma Meter. The texture parameters of hardness, springiness, cohesiveness, resilience, and chewiness for five formulations of the muffin were determined by using Texture Profile Analyzer. The proximate composition followed Association of Official Agricultural Chemists methods and was evaluated for moisture, ash, fat, protein, and fiber content. The value of L* (55.15 to 37.65), a* (13.64 to 11.02), and b* (39.50 to 19.14) decreased with an increased percentage of breadfruit flour incorporated in the muffin. The value of resilience, cohesiveness, springiness, and chewiness of all the formulations decreased while the hardness increased as the percentage of breadfruit flour in the muffin increased. The percentage of moisture, ash, and protein content gradually increased as the percentage of breadfruit flour increased. The muffin incorporated with breadfruit flour was high in fat and fiber content. In conclusion, the incorporation of 25 % breadfruit flour was recommended to be incorporated in muffin formulation as a higher substitution of breadfruit flour gives higher hardness and chewiness but lower springiness value compared to other formulations.

Keywords: Breadfruit, carbohydrate content, color properties, proximate analysis, texture analysis

Pengaruh buah sukun pada sifat fizikokimia muffin

ABSTRAK

Buah sukun mengandungi sejumlah besar kanji dan nutrient yang lain. Penyelidikan ini dijalankan untuk menentukan sifat fizikokimia dan sifat pemakanan muffin yang digabungkan dengan tepung buah sukun pada 25 % (F2), 50 % (F3), 75 % (F4), dan 100 % (F5). Muffin tanpa tepung buah sukun berfungsi sebagai muffin kawalan (F1). Sifat warna kecerahan (L*), kemerahan (a*), dan kekuningan (b*) tepung buah sukun dan muffin ditentukan menggunakan Chroma Meter. Parameter tekstur kekerasan, kekenyalan, kepaduan, ketahanan, dan kunyahan untuk lima formulasi muffin ditentukan dengan menggunakan Penganalisis Profil Tekstur. Komposisi proksikatur menggunakan kaedah Persatuan Ahli Kimia Pertanian Rasmi dan dinilai untuk kelembapan, abu, lemak, protein, dan kandungan serat. Nilai L* (55.15 kepada 37.65), a* (13.64 kepada 11.02), dan b* (39.50 kepada 19.14) menurun dengan peningkatan peratusan tepung buah sukun yang digabungkan ke dalam muffin. Nilai ketahanan, kepaduan, kekenyalan, dan kunyahan untuk semua formulasi menurun manakala kekerasan meningkat apabila peratusan tepung buah sukun dalam muffin meningkat. Peratusan kandungan kelembapan, abu, dan protein secara beransur-ansur meningkat apabila peratusan tepung buah sukun meningkat. Muffin yang digabungkan dengan tepung buah sukun adalah tinggi lemak dan kandungan serat. Kesimpulannya, penggabungan 25 % tepung buah sukun telah disyorkan untuk digabungkan ke dalam formulasi muffin kerana penggantian tepung buah sukun yang lebih tinggi memberikan kekerasan dan kunyahan yang lebih tinggi tetapi nilai kekenyalan yang lebih rendah berbanding formulasi yang lain.

Kata kunci: Analisis proksikatur, analisis tekstur, buah sukun, kandungan karbohidrat, sifat warna

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LIST OF SYMBOLS

$^{\circ}C$	Degree Celsius
%	Percent
±	Plus-minus
$<$	Less than

LIST OF ABBREVIATIONS

g	Gram
kg	Kilogram
ml	Milliliter
mm	Millimeter
LDPE	Low-density polyethylene
H_2SO_4	Sulfuric acid
NaOH	Sodium hydroxide
HCL	Acid Hydrochloric
AOAC	Association of Official Agricultural Chemists
SPSS	Statistical Package for the Social Science
SD	Standard Deviation
TPA	Texture Profile Analysis
ANOVA	Analysis of Variance
L*	Lightness
a*	Redness
b*	Yellowness

CHAPTER 1

INTRODUCTION

1.1 Research Background

Breadfruit (*Artocarpus artilis*) is a high-carbohydrate fruit that can be found in enormous quantities. Matured breadfruit can be consumed after cooking while ripe breadfruit can be eaten raw or processed into a snack (Ragone, 2012). Breadfruit can be baked, steamed, boiled, fried, microwaved, grilled, or barbequed (Liu, Brown, Ragone, Gibson & Murch, 2020). Breadfruit flour can be used to make bread, cakes, and pastries instead of wheat flour. Breadfruit and breadnut seeds were used to make nutritious baby food in Ghana, and Filipinos ate immature breadfruit as a vegetable (Ragone, 2012).

According to Shevkani et al. (2015), the muffin is a popular baked product and is admired by people because the taste is sweet and the texture is porous (Jeong & Chung, 2018). Rahman et al. (2015) mentioned that muffins are also high in calories. Muffins were produced from wheat flour, sugar, vegetable oil, eggs, and milk (Jeong & Chung, 2018). There are many types of muffins such as high-fiber muffins, free-sugar muffins, rich antioxidant muffins, and fat-free muffins, that have undergone research to enhance the nutritional value of muffins (Rahman et al., 2015).

1.2 Problem Statement

According to Akanbi, Nazamid & Adebowale (2009), utilization of the breadfruit crop is still not optimal and is often ignored (Estalansa, Yuniastuti & Hartati, 2018). According to Ragone (2011), people lack knowledge about the nutritional values and properties of breadfruit. In addition, there is limited support for research and development utilizing breadfruit. Breadfruit has not been widely used in food product development yet, but these plant sources have high dietary fiber. Furthermore, the research aims to determine a suitable formulation of food products to produce a low-fiber diet and gluten-free products by incorporating breadfruit flour. The food product development incorporated with breadfruit and flour is to address the deficiency of dietary fiber intake among Malaysians. Dietary fiber is resistant to digestion and absorption in the human small intestine. Sufficient intake of dietary fiber helps to improve gastrointestinal health and lower susceptibility to diseases such as heart disease, cancer, and diabetes. Dietary fiber is known to have health benefits (Căpriţă, Căpriţă, Simulescu & Drehe, 2010).

1.3 Hypothesis

H_0: Muffin incorporated with breadfruit flour has no effect on color, texture, and proximate composition

H_1: Muffin incorporated with breadfruit flour does have effect on color, texture, and proximate composition

1.4 Significance of the study

This study will be able to analyze the physicochemical of muffins incorporated with breadfruit flour. Besides, the scientific information will acknowledge people about the uses of breadfruit flour. Furthermore, the research will support and encourage food product developers to produce and commercialize new products from breadfruit since it is rare in Malaysia. The development of a variety of products with extended shelf life by using breadfruit flour can replace less healthy snacks.

1.5 Objectives

The objectives of this study are:

1) To determine the color and texture of muffins incorporated with breadfruit flour

2) To determine the proximate composition of muffins incorporated with breadfruit flour

CHAPTER 2

LITERATURE REVIEW

2.1 Breadfruit

Ragone (2011) stated that the scientific name for breadfruit is *Artocarpus altilis* from a mulberry family known as *Moraceae.* The usual name of breadfruit in the pacific islands is nimbalu (Solomon Islands), kapiak (Papuan New Guinea), buco (Fiji), and breadfruit (English). In the Asia regions, breadfruit is known as sukun (Indonesia), sa-ke (Thailand), rimas (Philippines), sake (Vietnamese), and rata del (Sri Langka).

The breadfruit trees can be grown during the hot, rainy, or summer months (Ragone, 2011). Breadfruit trees were fruiting three times a year with a high number of fruits produced (Olaoye & Onilude, 2008). Breadfruit is usually round, oval, or oblong. The weight of breadfruit is around 0.25 to 5 kg. The greenish-yellow skin of breadfruit is decorated with hexagonal markings while the surface is smooth, bumpy, or spiky. Breadfruit flesh is creamy white or pale yellow and the seeds are brown (Ragone, 2011).

Figure 2.1: Fresh breadfruit

The quality of breadfruit can be maintained while the shelf life can prolong by carefully handling the breadfruit during harvest and post-harvest after picking when the fruit is matured. Breadfruit only takes 1 to 3 days to ripen after harvest but the shelf life can be extended for a few days by pre-cooling the fruit in the ice or soaking it into the water during transportation (Ragone, 2011).

Breadfruit has the potential to become an alternative staple food to substitute rice due to its high carbohydrate and nutritional content (Estalansa, Yuniastuti & Hartati, 2018). The product made using breadfruit can be a solution to decrease world hunger (Nochera & Ragone, 2016). The production of breadfruit flour can assist local economies by the development of the local product to replace imported snacks (Ragone, 2011).

Ripened breadfruit can be eaten raw, cooked, and processed into flour or starch. Breadfruit becomes nutritious baby food in Ghana while immature breadfruit is a vegetable for Filipinos. People in the Solomon Islands eat Namba which is produced by roasting the whole breadfruit in a fire before slicing thinly and were roasted again to produce a desirable smoky flavor (Ragone, 2011). Puree made from breadfruit becomes porridge and breadfruit flour can be used in making bread or biscuits (Olaoye & Onilude, 2008).

Breadfruit has been popular fruit for centuries but the product made from breadfruit cannot gain the same attention from people (Graham & Bravo, 1981). Breadfruit was limited in usage due to the short shelf life of fresh breadfruit (Nochera & Ragone, 2019). Breadfruit can easily decay after harvest. The utilization of breadfruit in the food industries does not expand even though the fruit were high in nutritional content, less expensive, and abundant during the season (Abegunde, Bolaji, Adeyeye & Peluola-Adeyemi, 2019).

Breadfruit can extend shelf life by processing into breadfruit flour (Ajatta, Akinola & Osundahunsi, 2016). Breadfruit flour is a kind of stable storage form (Nochera & Ragone, 2016). Processing breadfruit into flour is a great way to decrease post-harvest losses and increase the utilization of breadfruit (Adepeju, Gbadamosi, Adeniran & Omobuwajo, 2011). Breadfruit flour was "Generally Recognized as Safe" by US Food and Drug Administration. Breadfruit flour can be utilized to produce a gluten-free product as value-added in chips, fries, dips, baked goods, desserts, or beverages (Nochera & Ragone, 2019).

2.2 Nutritional Composition of Breadfruit

Breadfruit is high in carbohydrates (Estalansa, Yuniastuti & Hartati, 2018). Ragone (2006) mentioned that the different growth locations and cultivars of breadfruit influence the level of copper, magnesium, phosphorus, potassium, calcium, iron, and manganese (Ishera, Mahendran & Roshana, 2021). Breadfruit is free from gluten. Breadfruit flour contains 7.6 % protein which is similar to rice but higher than other tropical staples (Nochera & Ragone, 2019). Breadfruit is affluent in fat, ash, fiber, and protein content (Olaoye & Onilude, 2008).

Breadfruit can be utilized as fat in making cookies (Li, Emelike & Sunday, 2016). According to Wang et al. (2011), breadfruit contains 0.31% fat, 1.34 % protein, 27.8 % carbohydrate, 1.5 % fiber, and 1.23 % ash. Akubor et al. (2000) found that breadfruit flour contains about 76.7 carbohydrates, 17.1 % protein, 11.1 fat, 3.0 % ash, and 0.1 % crude fiber (Ishera et al., 2021).

2.3 Chemical Composition of Breadfruit

Breadfruit was a great source of flavonoids while cooked breadfruit contains a low moderate glycemic index (Nochera & Ragone, 2019). Breadfruit flour with a low glycemic index is gluten-free. Ma'afala is one of a variety of breadfruit that can be found in Australia which has the highest essential amino acid compared to wheat, corn, rice, potato, and soybean. Breadfruit starch is useful in holding capacity, swelling power, and viscosity to merge wheat flour with water and oil (Liu et al., 2020).

The unique taste of breadfruit from Indonesia also comes with high resistant starch, amylose, and amylopectin. Landon et al. (2012) mentioned that starch from rice or corn has high-digestible starch compared to breadfruit. Septianingrum et al. (2016) found that breadfruit has higher resistance starch than rice, corn, cassava, potatoes, and wheat (Fitriani, Dieny, Margawati & Jauharany, 2021).

2.3 The muffins

People love muffins because of their good taste and porous texture (Ureta, Olivera & Salvadori, 2014). Muffin is one of the bakery products that through a dry heating process in an oven after a specific amount of flour mixed with many ingredients (Jauharah, Rosli & Robert, 2014). Wheat flour, vegetable oil, egg, and milk are a list of ingredients to produce muffins traditionally (Jeong & Chung, 2018). According to Foschia et al. (2013), people have normally consumed muffins in the morning as breakfast which they can prepare in a short time (Bender et al., 2017). Hadiyanto et al. (2007) mentioned that the baking process of muffins involved the heat operation and mass transfer process to develop dry surface crust while high internal temperature turns batters into crumb and product volume expansion. Temperature, time, and oven humidity can influence the quality of the muffin. People's choice is highly influenced by characteristics of surface crust color that is caused by a browning reaction due to caramelization sugar and Maillard reaction (Ureta et al., 2014).

2.4 Color measurement

A portable and handheld instrument known as Konica Minolta Chroma Meter CR400 is produced in Japan and can be used to measure the color and pigmentation of the food product. This instrument is beneficial to describe all colors that can be seen by the human eye. There are three different types of color values for each color measurement which L*, a*, and b*. The L* indicates brightness value or spectrum from black to white, a* indicates the value of color from redness to greenness, and b* indicates the value of color from blue to yellow. Furthermore, there is no additional software or training to operate the instrument (Lee et al., 2008).

2.5 Texture profile analysis

As stated by Rosenthal (2010), texture profile analysis (TPA) can provide measurement for texture attributes of food products to achieve food acceptability. The comparison of texture between dissimilar food products can be measured by using a TPA instrument. The texture parameters recorded for muffins were hardness, springiness, cohesiveness, resilience, and chewiness (Jauharah et al., 2014).

The hardness is a force to pre-determined deformation. Resilience is a measure of a product that regains its original position. The springiness value indicates a deformed sample returns to its original size and shape after the deforming force is removed. The cohesiveness value indicates the strength of internal bonds in the sample. The chewiness value indicates energy used to break the food into swallowing size (Rosenthal, 2010).

2.6 Proximate analysis

The percentage of moisture, ash, crude fat, crude protein, and crude fiber can be identified through proximate analysis (Mamat, Akanda, Zainol & Ling, 2018). Okafor & Ugwu (2014) found that high moisture content can cause the growth of microorganisms and lead the food product to spoilage (Ajatta, Akinola & Osundahunsi, 2016). As stated by Sidorova et al. (2017), the mineral substances contained in specific food samples are known as the ash content (Ishera et al., 2021). High-fat content encourages rancidity in a baked product that can cause off-flavors (Olaoye & Onilude, 2008). The crucial protein network in gluten is glutenin and gliadin that function to improve volume, texture, viscoelasticity, cohesiveness, and binding properties of the product (Nochera & Ragone, 2016). According to Esuoso and Bamiro (1995), crude fiber can help the digestive system in humans (Olaoye & Onilude, 2008). High water absorption in whole flour relates to high carbohydrate content (Adepeju, Gbadamosi, Adeniran & Omobuwajo, 2011).

CHAPTER 3

METHODOLOGY

3.1 Materials

3.1.1 Plant sample

The breadfruit was purchased through a local retailer at Kelantan, Malaysia.

3.1.2 Raw materials

The raw materials used for making muffins are flour, butter, sugar, baking powder, salt, egg, milk, and vanilla essence.

3.1.3 Chemicals

The chemical used in the proximate analysis is sulfuric acid, sodium hydroxide, hydrochloric acid, celite, boric acid, bromocresol green, methyl red indicator, Kjeldahl tablets, and petroleum ether.

3.1.4 Equipment

The equipment used in producing breadfruit flour is stainless steel dehydrator (PUNCAK), baking paper, electronic weighing balance, tray, sieve kitchen, and media bottle. The equipment used in making muffins are a pan, gas stove, microwave, muffin cup, grinder, chopping board, knife, spoon, ladle, plastic bowl, and portable seal. The equipment used for color measurement is Chroma Meter CR-400/410 (Konica Minolta, Japan). The equipment used in measuring the characteristics of products is Texture Analyzer (Brookfield CT3, USA). The equipment used in the proximate analysis are LDPE zipper bags (3 × 4 mm), beaker, measuring cylinder, conical flask, retort stand, Whatman filter paper, burette, plastic dropper, spatula, digestion tube, the crucible, aluminum dish, thimbles, aluminum cup, cotton, magnetic steel, hot plate, desiccator, Oven (105 ºC), Oven (Protech Model Fac-350H), Muffle Furnace (Protherm), Kjedahl Auto Distillation Analyzer (Gerhardt), Fat Analyzer (FOSS Soxtec^{TM} 2055), Auto Fiber Analysis System (Fibertex^{TM} 8000), Fume Hood (LaboFF), Furnace Carbolite (Gero 30-3000 ºC) and Kjeldahl Digestion (Gerhardt).

3.2 Method

3.2.1 Preparation of breadfruit flour

The breadfruit was washed to remove dirt and unwanted materials. The skin of the breadfruit was peeled. The breadfruit was sliced thinly prior spread on pre-layered baking paper. Then, the breadfruit was dried in a dehydrator at 60 ºC overnight. The dried breadfruit was ground until turned into powder form. The breadfruit flour was sieved to remove coarse particles. Lastly, the breadfruit was stored in an airtight container.

3.2.2 Preparation of muffins incorporated with breadfruit flour

There are four formulations of muffin incorporated with breadfruit flour and one formulation for muffin control was prepared (Table 3.1). Self-rising flour, breadfruit flour, baking powder, and salt were sieved thoroughly. Melted butter, sugar, and egg were whisked together before milk and vanilla essence was added and were blended for 2 minutes. All the ingredients were mixed and stirred until blended well. The 40 g of batter was poured into each of the muffin cups. Three muffin cups were arranged in two rows of one baking tray. The batters were baked twice, which was baked at 210 ºC for 5 minutes in a preheated oven and continued baking at 180 ºC for 12 minutes. The muffin was incorporated with breadfruit flour as the end product was left to cool at room temperature for 1 hour. Once the end product was cooled, it was packed, sealed, and labeled for color measurement, and to determine the textural properties and proximate analysis.

Table 3.1: Formulation of muffin incorporated with breadfruit flour

Ingredient	**Formulation**				
	F1 (Control)	**F2 (25 % of breadfruit flour)**	**F3 (50 % of breadfruit flour)**	**F4 (75 % of breadfruit flour)**	**F5 (100 % of breadfruit flour)**
Breadfruit flour	-	41 g	82.5 g	124 g	165 g
Self-rising flour	165 g	124 g	82.5 g	41 g	-
Sugar	70 g	70 g	70 g	70 g	70 g
Baking powder	2.5 g	2.5 g	2.5 g	2.5 g	2.5 g
Salt	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g
Egg	56.5 ml	56.5 ml	56.5 ml	56.5 ml	56.5 ml
Butter	50 g	50 g	50 g	50 g	50 g
Milk	150 ml	150 ml	150 ml	150 ml	150 ml
Vanilla essence	5 ml	5 ml	5 ml	5 ml	5 ml
TOTAL	500	500	500	500	500

3.2.3 Determination of proximate analysis

The proximate analysis of the muffin incorporated with breadfruit flour for moisture, ash, crude fat, crude protein, and crude fiber was performed according to AOAC specifications (AOAC, 2000). The samples are including muffin control (F1), muffin incorporated with 25 % of breadfruit flour (F2), and muffin substitute flour with 100 % of breadfruit flour (F5). The sample for proximate analysis was chopped and dried in an oven at 60 ^{o}C for 24 hours except for a sample of moisture content that was used from the fresh sample. All the samples were weighed and stored in an LDPE zipper bag until proximate analysis was carried out. All the samples were performed in triplicates.

3.2.3.1 Moisture content

The aluminum dish was dried in an oven at 105 ^{o}C for 1 hour. The dried aluminum dish containing 2 g of sample was through a drying process in an oven at 110 ^{o}C for 4 hours. The final weight was recorded after being cooled in a desiccator for 20 minutes. The percentage of moisture content was determined by using the formula below.

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

3.2.3.2 Ash content

Crucible was dried in an oven at 105 ºC for 1 hour. The dried crucible was added with 1 g of the sample before being heated in a muffle furnace at 600 ºC for 20 minutes. The muffle furnace took overnight for temperature dropped at 60 ºC after turning off the machine. The crucible and ash were weighed after being cooled in a desiccator for 20 minutes. The percentage of ash was determined by using the formula below.

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

3.2.3.3 Crude fat

Fat analyzer (FOSS Soxtec^{TM} 2055) was used to analyze the fat content of the sample. The aluminum cup was dried at 105 ºC for 20 minutes. 80 ml of petroleum ether was poured into the dried aluminum cup after the cup was cooled. 1 g of sample was wrapped in the filter paper before being set down into a thimble that was pre-layered with cotton. Then, another cotton was used to fully cover that filter paper containing the sample. The aluminum cup containing fat was dried in the oven at 105 ºC for 20 minutes after the fat was analyzed. The weight of the aluminum cup with fat was weighed after cooled in a desiccator for 20 minutes. The sample that was wrapped with filter paper can be used for fiber analysis after a thorough drying process in the oven at 105 ºC for 30 minutes. The percentage of fat content was determined by using the formula below.

$$\text{Fat (\%)} = \frac{(\text{Weight of aluminum cup} + \text{fat}) - (\text{Weight of aluminum cup})}{\text{Initial weight of sample}} \times 100$$

3.2.3.4 Crude Protein

The Kjeldahl method was used to determine the percentage of nitrogen in the sample. 1 g of sample was mixed with 12 ml H_2SO_4 and Kjeldahl tablets (catalyst) in the digestion tube before were pre-heated at 400 ºC for 2 hours until the solution became colorless. The sample solution was allowed to cool for 20 minutes after the digestion processes finished. The sample solution was diluted with 80 ml distilled water followed by 50 ml NaOH prior distillation process. Before the distillation process, the nitrogen receiver was prepared by 4 % of boric acid solution added with bromocresol green and methyl red indicator. Each receiver contains 30 ml of boric acid solution. The distillation process took 2 minutes to change the color of the receiver solution from red to green to indicate the presence of nitrogen that was transferred from the sample solution. The distillation system needed to be cleaned before and after the distillation process by using distilled water. The volume of HCL used in the titration process was recorded once the receiver turned color from green to red. A conversion factor of 6.25 was used to convert the measured nitrogen content to protein. This method consists of finding the percentage of nitrogen followed by the determination of protein percentage.

$$\text{Kjedahl Nitrogen} = \frac{(\text{Vs} - \text{Vb}) \times \text{N} \times 14.01}{\text{W} \times 1000} \times 100$$

Vs: ml of standardized acid used to titrate a sample

Vb: ml of standardized acid used to titrate blank

N: Normality of standard HCl

W: Weight in g of sample or standard

Crude protein (%) = Kjeldahl Nitrogen (%) x F

F: Factors to convert nitrogen to protein

3.2.3.5 Fiber content

1.25 % of H_2SO_4 and 1.25 % of NaOH were prepared as for lubricant to the Auto Fiber Analysis System. 1 spoon of celite (catalyst) was mixed with 1 g of sample in a glass container. The sample was processed in the Auto Fiber Analysis System for 2 hours and a half. Then, the sample was pre-heated in the oven at 130 ºC for 2 hours before being heated in Furnace Carbolite at 525 ºC for 6 hours. The sample was weighed after were cooled in a desiccator. The percentage of crude fiber was determined by using the formula below.

$$\text{Crude fiber \%} = \frac{\text{Weight of crucible with fiber} - \text{Weight of Crucible with ash}}{\text{Weight of sample}} \times 100$$

3.2.3.6 Carbohydrate content

The carbohydrate content was determined by using the formula below.

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

3.2.4 Determination of texture properties

TPA was conducted by using Texture Analyzer (Brookfield CT3, USA). The probe involved was TA4/1000 (Cylinder 38.1 mm diameter and 20 mm length). The soft inner portion of the muffin was evaluated. Each muffin was cut into a 2.5 cm sided cube and the upper crust was removed. The test was performed by compressing twice, the test target was distance, the cylinder probe was at a speed of 10.00 mm/s and the trigger load was 5 g. The texture parameters recorded were hardness, springiness, cohesiveness, resilience, and chewiness of muffin samples (Jauharah, Rosli & Robert, 2014).

3.2.5 Determination of color properties

The color measurement of breadfruit flour and muffin incorporated with breadfruit flour was implemented by using Chroma Meter CR-400/410 (Konica Minolta, Japan). The result has been recorded in the form of the L* a* b* color space. Each sample was triplicate.

3.2.6 Statistical analysis

Each measurement for statistical analysis was conducted in triplicate. The experimental data were subjected to analyses the mean, standard deviation, and one-way ANOVA. The significant level at $p < 0.05$ was determined. The experimental data were analyzed using software IBM SPSS Statistics 20.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Breadfruit flour

The picture in Figure 4.1 shows breadfruit flour was produced from breadfruit as an ingredient to be incorporated in the muffin preparation. The yield of the breadfruit flour is 636.03 g that was 16% of fresh fruit.

Figure 4.1: Breadfruit flour

4.2 Color of breadfruit flour

Breadfruit flour has been analyzed for properties as shown in Table 4.1.

Table 4.1: Mean and standard deviation (mean ± SD) for the color of breadfruit flour

Color	L*	a*	b*
Breadfruit flour	75.41 ± 0.45	6.42 ± 0.05	26.47 ± 0.17

Table 4.1 showed the high value of L* (lightness) indicates the color of breadfruit flour is light. The positive value of a* indicates it had slightly redness color and the positive value of b* indicates its yellowness. The yellowness of the breadfruit flour was higher than wheat flour (8.48) but had lower value compared to peeled pumpkin pulp flour (53.83) and unpeeled pumpkin pulp flour (49.45) (Aziah & Komathi, 2009).

4.3 Muffin incorporated with breadfruit flour

The muffins for five formulations were prepared. The photograph of muffins incorporated with different percentages of breadfruit flour were shown in in figure 4.2.

Formulation (F)	Product image	Percentage of breadfruit flour
F1 (Control)		100 % flour
F2		25 % breadfruit flour

F3		50 % breadfruit flour
F4		75 % breadfruit flour
F5		100 % breadfruit flour

Figure 4.2: Picture of muffin incorporated with breadfruit flour

4.4 Color properties of muffin incorporated with breadfruit flour

The muffin incorporated with breadfruit flour has been analyzed for color properties as shown in Table 4.2.

Table 4.2: Mean and standard deviation (mean ± SD) of color properties

Color	L*	a*	b*
F1 (Control)	73.16 ± 2.68[a]	3.75 ± 3.44[c]	36.54 ± 5.31[ab]
F2	55.15 ± 3.68[b]	13.64 ± 0.18[ab]	39.50 ± 0.66[a]
F3	44.39 ± 2.24[c]	17.30 ± 1.89[a]	31.41 ± 1.18b[c]
F4	41.51 ± 1.63[cd]	13.66 ± 2.81[ab]	25.46 ± 2.30[cd]
F5	37.65 ± 1.18[d]	11.02 ± 0.38[b]	19.14 ± 1.59[d]

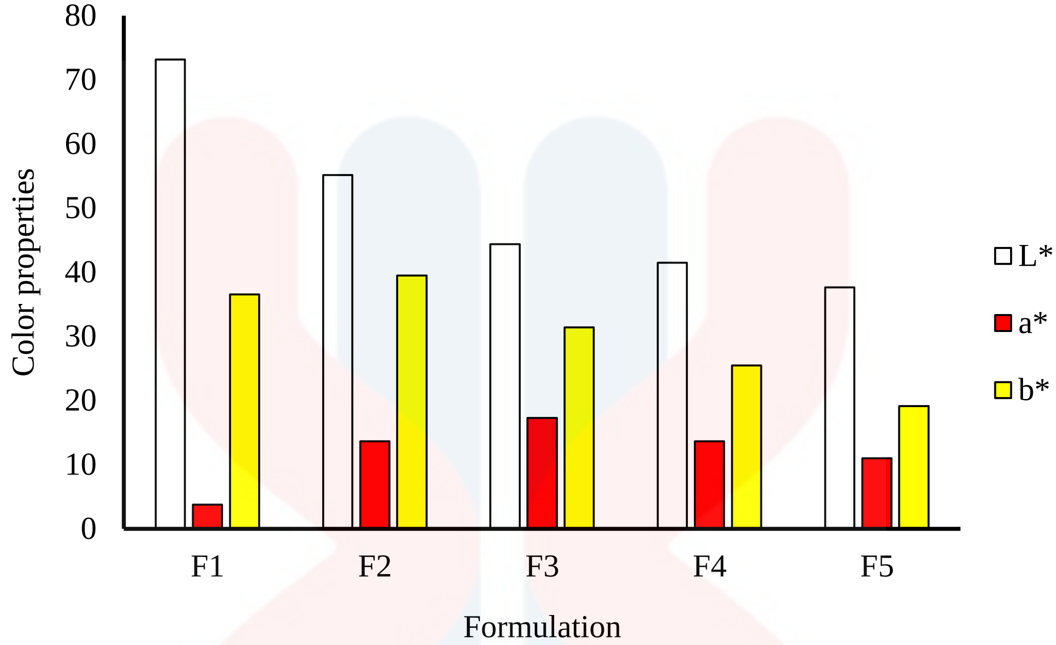

Figure 4.3: Mean of color properties for muffin incorporated with breadfruit flour

Table 4.2 showed as the increased of the percentage of breadfruit flour, the lightness of the muffin incorporated with breadfruit flour had decreased. The redness of the muffins had decreased with increased level of breadfruit flour. The yellowness of muffins incorporated with breadfruit flour decreased as the percentage of breadfruit flour increased.

The lightness of the control muffin was significantly higher than the muffin containing 25 % of breadfruit flour, 50 % of breadfruit flour, 75 % of breadfruit flour and 100 % of breadfruit flour. The lightness of muffins containing 25 % and 50 % of breadfruit flour was significant. The lightness of muffins containing 50 %, 75 % and 100 % of breadfruit flour was not significant. Meanwhile, the redness of the control muffin was significantly lower than the muffin containing 25 %, 50 %, 75 % and 100 % of breadfruit flour. The redness of muffins containing 25 %, 50 %, 75 % and 100 % of breadfruit flour was not significant. The yellowness of the control muffin and muffin containing 25 % of breadfruit flour was significantly higher than the muffin containing 50 %, 75 % and 100 % of breadfruit flour. The yellowness of muffins containing 50 %, 75 % and 100 % of breadfruit flour was not significant.

According to Shevkani et al. (2015), the color of muffins plays an important role in the quality evaluation of muffins (Jeong & Chung, 2018). Hence, the substitution of breadfruit flour in the formulation affected the color of the muffin. The muffins with lower level of breadfruit flour were had lighter color and it was in line with formulation 2.

4.5 Texture Profile Analysis of muffin incorporate with breadfruit flour

Muffin incorporated with breadfruit flour has been analyzed for texture profile attributes as shown in table 4.3 to table 4.7.

Table 4.3: Mean and standard deviation (mean ± SD) of hardness

Sample	mean ± SD
F1 (Control)	4866 ± 2030.28[a]
F2	2744 ± 532.36[a]
F3	9325 ± 2151.02[a]
F4	10244 ± 850.32[a]
F5	7131 ± 6182.17[a]

Table 4.3 showed the hardness of muffins incorporated with breadfruit flour. The hardness increased as the percentage of breadfruit flour increased. The muffin consists of 75 % breadfruit flour mixed with 25 % wheat flour has the highest maximum force for compression followed by the muffin incorporated with 50 % of breadfruit flour and the muffin incorporated with 100 % breadfruit flour. The muffin containing the least percentage of breadfruit flour has a lower maximum force for compression compared to the control muffin. The hardness of the control muffin and muffin containing 25 %, 50 %, 75 %, and 100 % of breadfruit flour was not significant.

The texture of batters for muffins containing 50 %, 75 %, and 100 % of breadfruit flour became more dried after the percentage of breadfruit flour incorporated with muffin was increased. However, muffin incorporated with 75 % breadfruit flour has the highest quantity of breadfruit flour mixed with 25 % wheat flour compared to muffin made using 100 % breadfruit flour. According to Huang et al. (2019), the hardness of structure becomes increases when the quantity of water from batters is reduced during the cooking process or due to the addition of wheat flour. Salehi & Kashaninejad (2018) found that sponge cake added with quince powder became more rigid because of the loss of free water in the cake. Miguel et al. (1999) mentioned that the increasing density of muffins and reduction number of air pockets caused muffins incorporated with the peach dietary increase in hardness (Jauharah, Rosli & Robert, 2014).

As stated by Hellen et al. (2014), the hardness of bread incorporated with cowpea flour increased due to the structure of bread became denser. Gularte et al. (2012) found that the decrease in the amount and size of muffin air bubbles causes the hardness of muffin containing legume flours to increase. The shortage of wheat gluten and excellent water absorption causes the muffins containing legume flour to increase in hardness. The poor ability to surround by air causes muffins incorporated with legume flour to become denser due to a reduction in gluten forming structure (Jeong & Chung 2018).

According to Hadiyanto et al. (2007) the baking process of muffins involved the heat operation and mass transfer process that developed dry surface crust while high internal temperature turns batters into crumb and the volume of product become expansion (Ureta et al., 2014).

Table 4.4: Mean and standard deviation (mean ± SD) of resilience

Sample	mean ± SD
F1 (Control)	0.08 ± 0.01^{ab}
F2	0.09 ± 0.00^{a}
F3	0.09 ± 0.01^{a}
F4	0.05 ± 0.01^{b}
F5	0.01 ± 0.01^{c}

Table 4.4 showed the resilience of muffins incorporated with breadfruit flour decreased as the percentage of breadfruit flour increased. The muffin incorporated with 100 % of breadfruit flour acquired the lowest speed and force to regain original height after the first compression compared to all the formulations.

The resilience of muffins containing 100 % breadfruit flour was significantly lower than the control muffin and muffins containing 25 %, 50 % and 75 % of breadfruit flour. The resilience of control muffins and muffins containing 25 %, 50 % and 75 % of breadfruit flour was not significant. The resilience of muffins containing 75 % of breadfruit flour was significantly lower than the muffin containing 25 % and 50 % of breadfruit flour.

As increased hardness in muffins incorporated with breadfruit flour, the resilience of the muffin incorporated with breadfruit flour decreased. According to Hamzacebi & Tacer-Caba (2021), the decrease in resilience correlates with the increase in hardness and cohesiveness.

The decreased value in the resilience of muffin incorporated with breadfruit flour indicated the product became denser. The result obtained from this study is similar to the research from Jauharah, Rosli, & Robert (2014) which found that the denser of muffin supplemented with young corn powder influenced the value of resilience became decrease. With the increased amount of resistant starch incorporated with a muffin, the product became denser and the resilience value decreased (Baixauli, Salvador & Fiszman 2008).

Table 4.5: Mean and standard deviation (mean ± SD) of cohesiveness

Sample	mean ± SD
F1 (Control)	0.23 ± 0.03^{a}
F2	0.23 ± 0.01^{a}
F3	0.28 ± 0.06^{a}
F4	0.27 ± 0.05^{a}
F5	0.09 ± 0.08^{b}

Table 4.5 showed the cohesiveness of muffins incorporated with breadfruit flour decreased as the percentage of breadfruit flour increased. The cohesiveness of muffins containing 100 % breadfruit flour was significantly lower than the control muffin and muffins containing 25 %, 50 % and 75 % of breadfruit flour. The cohesiveness of control muffins and muffins containing 25 %, 50 % and 75 % of breadfruit flour was not significant.

However, all the formulations that contain wheat flour mixed with breadfruit flour have a higher strength of internal bonds in the muffin to resist tensile stress than muffin incorporated with 100 % breadfruit flour. The internal resistance of food structure is evaluated by cohesiveness (Rahman et al., 2015). Jauharah et al. (2014) found that the cohesiveness of muffins incorporated with young corn powder was significantly lower than the control muffins. Salehi & Kashaninejad (2018) stated that the cohesiveness was decreased as the 0 to 15 % of quince powder incorporated with cake increased.

As mentioned by Nochera & Ragone (2019), the delivery of cohesive breadfruit pasta products involves proper ingredients chosen that would provide essential binding capacity toward a product. The major component of protein in gluten known as glutenin and gliadin are functions for cohesiveness and binding effects. Muffin products with a lower value of cohesiveness, chewiness, and hardness will be well qualified to be commercialized (Joshi, Sagar, Sharma & Singh, 2018).

Table 4.6: Mean and standard deviation (mean ± SD) of springiness

Sample	mean ± SD
F1 (Control)	1.13 ± 0.02[a]
F2	1.47 ± 0.71[a]
F3	1.13± 0.02[a]
F4	1.02 ± 0.16[a]
F5	0.61 ± 0.53[a]

Table 4.6 showed the springiness of muffins incorporated with breadfruit flour decreased as the percentage of breadfruit flour increased. The muffin incorporated with 100 % of breadfruit flour has the shortest value for deformed muffin return undeformed after the force was removed compared to all the formulations that contain wheat flour. The springiness of control muffins and muffins containing 25 %, 50 %, 75 % and 100 % of breadfruit flour was not significant.

The decreased value in the springiness of muffin incorporated with breadfruit flour indicated the product become denser. Salehi & Kashaninejad (2018) found that control bread has higher springiness than bread incorporated with 5 % of fiber from rice straw. Gomez et al. (2010) found that muffin incorporated with 6 to 10 % of seaweed powder has a significantly lower value of springiness than control muffin (Mamat, Md, Akanda, Zainol, & Ling, 2018). As stated by Rahman et al. (2015) the amount of air bubbles present during the mixing process of muffin is correlated to springiness. According to Sanz et al. (2009) when muffin air bubbles are reduced and the final product becomes denser, the springiness of the product will decrease (Jauharah et al., 2014).

Table 4.7: Mean and standard deviation (SD) of chewiness

Sample	mean ± SD
F1 (Control)	120.90 ± 39.99[ab]
F2	91.40 ± 33.39[b]
F3	288.13 ± 47.59[a]
F4	280.30 ± 103.49[a]
F5	88.83 ± 77.14[b]

Table 4.5 showed the chewiness of muffins incorporated with breadfruit flour decreased as the percentage of breadfruit flour increased. The muffin incorporated with 50 % of breadfruit flour required the highest energy to chew the product until ready to swollen followed by the muffin incorporated with 75 % breadfruit flour. The muffin incorporated with 100 % of breadfruit flour required the lowest energy to chew the product followed by the muffin incorporated with 25 % of breadfruit flour compared to the control muffin. However, the value of chewiness for muffins made using 100 % breadfruit flour was suddenly decreased. According to Nochera & Ragone (2019), originally breadfruit does not contain gluten which is responsible for the elastic texture of dough.

The chewiness of muffins containing 25 % and 100 % of breadfruit flour was significantly lower than muffins containing 50 % and 75 % of breadfruit flour. The chewiness of muffins containing 25 %, 50 %, 75 %, and 100 % of breadfruit flour was not significant compared to the control muffins.

Joshi et al. (2018) found that muffins incorporated with 1 to 7 % of potato flour that has higher size particles compared to wheat flour were decreased in chewiness due to potato flour being pasted during baking. According to Salehi & Kashaninejad (2018), as the increased percentage of quince powder from 0 to 10 %, the chewiness of cake incorporated with quince powder decreased. The chewiness value decreases when the food product is easy to chew before swallowing. Muffin products with a lower value of chewiness will be well qualified to be commercialized (Joshi et al., 2018).

4.6 Proximate analysis of muffin incorporated with breadfruit flour

The control muffin (F1), muffin with the lowest percentage of breadfruit flour which is 25 % (F2) and muffin with the highest of breadfruit flour which is 100 % (F5) has been chosen for analysis of the percentage of moisture, ash, fat, protein and fiber content.

Table 4.8: Mean and standard deviation (mean ± SD) of moisture content

Moisture Content	
F1 (Control)	33.20 ± 0.52[a]
F2	31.93 ± 1.24[a]
F5	32.90 ± 1.37[a]

Table 4.8 showed the moisture content of muffins incorporated with breadfruit flour gradually increase as the percentage of breadfruit flour increased. The moisture content of control muffins and muffins containing 25 % breadfruit flour and 100 % breadfruit flour was not significant. However, the muffin incorporated with 25 % breadfruit flour has the lowest moisture content compared to the control muffin.

This result obtained can be supported by research from Tijani, Oke, Bakare & Tayo (2017). According to Tijani et al. (2017), the noodles incorporated with 10 % of breadfruit flour have a lower moisture content which ranged from 2.50 to 3.50 % than the noodles produced from 100% of wheat flour which 3.50 % of moisture content. Ishera, Mahendran & Roshana (2021) mentioned that the moisture content of cookies incorporated with 0 to 100 % of breadfruit flour was from 3.37 to 4.43 %. Tijani et al. (2017) found that products with high moisture can easily spoilage. A product with high moisture content cannot be stored for a long period. Therefore, the bread incorporated with 25 % of breadfruit flour has a short shelf life (Olaoye & Onilude, 2008).

Table 4.9: Mean and standard deviation (mean ± SD) of ash content

	Ash Content
F1 (Control)	17.57 ± 3.09[a]
F2	12.93 ± 0.35[a]
F5	13.57 ± 1.12[a]

Table 4.9 showed the ash content of muffins incorporated with breadfruit flour gradually increase as the percentage of breadfruit flour increased. The ash content of control muffins and muffins containing 25 % breadfruit flour and 100 % breadfruit flour was not significant. However, muffin control has the highest ash content compared to muffins incorporated with 100 % breadfruit flour. These findings cannot be supported by Ragone (1997) and Ishera et al. (2021). Ragone (1997) found that wheat consists of lower ash content compared to breadfruit. As the percentage of breadfruit increases, the ash content will be increase. According to Adepeju et al. (2015), the percentage of ash content in wheat flour which is 0.51 % is lower than breadfruit flour which is 2.67 % (Ishera et al., 2021).

Additionally, noodles produced from 100 % of wheat flour have lower ash content than the noodles incorporated with 50 % of breadfruit flour. The percentage of ash content present in noodles incorporated with breadfruit and wheat flour mixture ranged between 0.80 to 1.74 %. Therefore, the minerals of noodles will increase as the replacement of breadfruit flour increases (Tijani et al., 2017).

Table 4.10: Mean and standard deviation (mean ± SD) of fat content

	Fat Content
F1 (Control)	45.00 ± 5.21^{b}
F2	53.03 ± 5.91^{b}
F5	94.50 ± 1.28^{a}

Table 4.10 showed the fat content of muffins incorporated with breadfruit flour greatly increase as the percentage of breadfruit flour increased. The muffin incorporated with 100 % of breadfruit flour has the highest fat content compared to the control muffin. The fat content of muffins containing 100 % breadfruit was significantly lower than the control muffin and muffins containing 25 % breadfruit flour. The fat content of the control muffin and muffins containing 25 % breadfruit flour was not significant.

This result obtained is opposite with research of cookies made using breadfruit flour. As stated by Barber et al. (2016), the percentage of cookies produced from 100 % of wheat flour which is 20.41 % was higher in fat content than cookies produced from 100% of breadfruit flour which is 14.71 % (Ishera et al., 2021). However, Ibanga & Oladele (2008) found that the fat content of cassava and maize flour is lower than breadfruit flour (Adepeju, Gbadamosi, Adeniran, & Omobuwajo, 2011). Therefore, muffin incorporated with breadfruit flour is rich in fat content. Odoemelam (2003) mentioned that food containing fats can enhance the flavor and mouthfeel of foods (Adepeju et al., 2011). Furthermore, high-fat content also can lead to rancidity, off-flavors and produce an undesirable odor of baked food products (Olaoye & Onilude, 2008).

Table 4.11: Mean and standard deviation (mean ± SD) of protein content

Protein Content	
F1 (Control)	17.33 ± 0.85^a
F2	14.70 ± 0.90^a
F5	15.87 ± 2.21^a

Table 4.11 showed the protein content of muffins incorporated with breadfruit flour gradually increase as the percentage of breadfruit flour increased. The protein content of control muffins and muffins containing 25 % breadfruit flour and 100 % breadfruit flour was not significant.

However, muffin control has the highest protein content compared to muffins incorporated with 25 % and 100 % of breadfruit flour. These findings were supported by research from Ishera et al. (2021). Udio et al. (2003) found that the protein content of breadfruit flour is lower compared to the protein content in wheat flour (Ishera et al., 2021). Olaoye & Onilude (2008) mentioned that the crude protein in biscuits incorporated with breadfruit flour was decreased as the quantity of breadfruit flour increased. Vasantha et al. (2008) found that the protein content of muffins was lowered when incorporated with high fiber fruits to substitute wheat flour (Mamat et al., 2018). According to Jones et al. (2021), the protein in breadfruit is 1.1 % higher than in a banana with an average of 3.9 % of protein (Liu, Ragone, & Murch, 2015).

Table 4.12: Mean and standard deviation (mean ± SD) of the fiber content

Fiber Content	
F1 (Control)	2.00 ± 0.60[c]
F2	4.53 ± 0.49[b]
F5	10.33 ± 0.29[a]

Table 4.12 showed the fiber content of muffin incorporated with breadfruit flour increased as the percentage of breadfruit flour increased. The muffin incorporated with 100 % breadfruit flour has the highest fiber content compared to the control muffin. The fiber content of the control muffin was significantly lower than muffins containing 25 % breadfruit flour and 100 % breadfruit flour. The fiber content of muffins containing 100 % breadfruit flour was significantly higher than the control muffin and muffins containing 25 % breadfruit flour. the fiber content of the control muffin, muffins containing 25 % breadfruit flour and muffins containing 100 % breadfruit flour was significant.

Composite flour consists of wheat flour, rice flour, green flour and potato flour were blended (Chandra, Singh & Kumari, 2015). As the increased percentage of breadfruit flour substituted composite flour caused the crude fiber of bread incorporated with breadfruit flour was increased (Olaoye & Onilude, 2008). Nochera & Ragone (2019) found that there are 7.37 g of crude fiber contained in 100 g of cooked breadfruit. The fat content of cookies incorporated with 0 to 100 % breadfruit flour was increased from 0.97 to 3.02 %. Fiber from the source of the plant can enhance the color, texture and aroma of cookies (Ishera et al., 2021). According to Slavin (2015), one alternative to prevent constipation and cardiovascular disease by consuming fiber (Tijani et al., 2017).

Table 4.13: Mean and standard deviation (mean ± SD) of carbohydrate content

Carbohydrate content	
F1 (Control)	50.46 ± 5.32^{a}
F2	50.84 ± 3.25^{a}
F5	23.08 ± 4.07^{b}

Table 4.13 showed the carbohydrate content of muffin incorporated with breadfruit flour decreased as the percentage of breadfruit flour increased. The muffin incorporated with 100 % breadfruit flour has the lowest carbohydrate content compared to the control muffin. The carbohydrate content of muffins containing 100 % breadfruit flour was significantly lower than the control muffin and muffins containing 25 % breadfruit flour. The carbohydrate content of the control muffin and muffin containing 25 % breadfruit flour was not significant.

The muffin containing 25 % breadfruit flour mixed with 75 % wheat flour is high in carbohydrate content. The result obtained can be supported by research from Ishera et al. (2021). The carbohydrate content of cookies incorporated with breadfruit and wheat flour mixture increased from 59.92 to 64.93% when the percentage of breadfruit flour incorporated with cookies increased from 0 to 100 %. According to Malomo et al. (2011), the carbohydrate content in wheat flour is 72.5 %. Akubor et al. (2000) found that breadfruit flour consists of

76.7% carbohydrates. The cookies made by breadfruit flour and wheat flour mixture are high in carbohydrates. According to Wang et al. (2011), breadfruit contains 0.31% fat, 1.34 % protein, 27.8 % carbohydrate, 1.5 % fiber and 1.23 % ash (Ishera et al., 2021).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

The substitution of breadfruit flour in muffin preparation has influenced the color and textural properties of the muffins. The higher percentage of the flour used has decreased the value of lightness (L*), redness (a*), and yellowness (b*) of muffin. As the percentage of breadfruit flour increased, the value of resilience, cohesiveness, springiness, and chewiness of the product became decreased while the hardness was increased. The percentage of moisture, ash, and protein content gradually increased as the percentage of breadfruit flour increased. The muffin incorporated with breadfruit flour was high in fat and fiber content. Based on five different formulations, it is recommended that breadfruit flour is best incorporated in muffins at the level of 25 %. The incorporation of breadfruit flour higher than 50% will increase the value of hardness and chewiness and decrease the lightness of muffins color which might decrease consumers' preferences.

Therefore, further investigation in dietary fiber content, starch content, and sensory evaluation will provide improvement to this research.

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APPENDIX A: SPSS OUTPUT

L* of muffin incorporated with breadfruit flour in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2454.695	4	613.674	103.068	.000
Within Groups	59.541	10	5.954		
Total	2514.236	14			

a* of muffin incorporated with breadfruit flour in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	307.311	4	76.828	16.347	.000
Within Groups	46.999	10	4.700		
Total	354.311	14			

b* of muffin incorporated with breadfruit flour in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	817.956	4	204.489	26.926	.000
Within Groups	75.945	10	7.594		
Total	893.900	14			

Multiple comparison L* of muffin incorporated with breadfruit flour

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	18.01000*	1.99233	.000	11.4531	24.5669
	F3	28.77000*	1.99233	.000	22.2131	35.3269
	F4	31.64667*	1.99233	.000	25.0897	38.2036
	F5	35.51000*	1.99233	.000	28.9531	42.0669
F2	F1	-18.01000*	1.99233	.000	-24.5669	-11.4531
	F3	10.76000*	1.99233	.002	4.2031	17.3169
	F4	13.63667*	1.99233	.000	7.0797	20.1936
	F5	17.50000*	1.99233	.000	10.9431	24.0569
F3	F1	-28.77000*	1.99233	.000	-35.3269	-22.2131
	F2	-10.76000*	1.99233	.002	-17.3169	-4.2031
	F4	2.87667	1.99233	.616	-3.6803	9.4336
	F5	6.74000*	1.99233	.043	.1831	13.2969
F4	F1	-31.64667*	1.99233	.000	-38.2036	-25.0897
	F2	-13.63667*	1.99233	.000	-20.1936	-7.0797
	F3	-2.87667	1.99233	.616	-9.4336	3.6803
	F5	3.86333	1.99233	.358	-2.6936	10.4203
F5	F1	-35.51000*	1.99233	.000	-42.0669	-28.9531
	F2	-17.50000*	1.99233	.000	-24.0569	-10.9431
	F3	-6.74000*	1.99233	.043	-13.2969	-.1831
	F4	-3.86333	1.99233	.358	-10.4203	2.6936

*. The mean difference is significant at the 0.05 level.

Multiple comparison a* of muffin incorporated with breadfruit flour

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	-9.88333*	1.77011	.002	-15.7089	-4.0577
	F3	-13.55000*	1.77011	.000	-19.3756	-7.7244
	F4	-9.90333*	1.77011	.002	-15.7289	-4.0777
	F5	-7.26667*	1.77011	.014	-13.0923	-1.4411
F2	F1	9.88333*	1.77011	.002	4.0577	15.7089
	F3	-3.66667	1.77011	.302	-9.4923	2.1589
	F4	-.02000	1.77011	1.000	-5.8456	5.8056
	F5	2.61667	1.77011	.597	-3.2089	8.4423
F3	F1	13.55000*	1.77011	.000	7.7244	19.3756
	F2	3.66667	1.77011	.302	-2.1589	9.4923
	F4	3.64667	1.77011	.307	-2.1789	9.4723
	F5	6.28333*	1.77011	.033	.4577	12.1089
F4	F1	9.90333*	1.77011	.002	4.0777	15.7289
	F2	.02000	1.77011	1.000	-5.8056	5.8456
	F3	-3.64667	1.77011	.307	-9.4723	2.1789
	F5	2.63667	1.77011	.590	-3.1889	8.4623
F5	F1	7.26667*	1.77011	.014	1.4411	13.0923
	F2	-2.61667	1.77011	.597	-8.4423	3.2089
	F3	-6.28333*	1.77011	.033	-12.1089	-.4577
	F4	-2.63667	1.77011	.590	-8.4623	3.1889

*. The mean difference is significant at the 0.05 level.

Multiple comparison b* for muffin incorporated with breadfruit flour

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	-2.95333	2.25011	.690	-10.3586	4.4520
	F3	5.13667	2.25011	.227	-2.2686	12.5420
	F4	11.08667*	2.25011	.004	3.6814	18.4920
	F5	17.40000*	2.25011	.000	9.9947	24.8053
F2	F1	2.95333	2.25011	.690	-4.4520	10.3586
	F3	8.09000*	2.25011	.031	.6847	15.4953
	F4	14.04000*	2.25011	.001	6.6347	21.4453
	F5	20.35333*	2.25011	.000	12.9480	27.7586
F3	F1	-5.13667	2.25011	.227	-12.5420	2.2686
	F2	-8.09000*	2.25011	.031	-15.4953	-.6847
	F4	5.95000	2.25011	.135	-1.4553	13.3553
	F5	12.26333*	2.25011	.002	4.8580	19.6686
F4	F1	-11.08667*	2.25011	.004	-18.4920	-3.6814
	F2	-14.04000*	2.25011	.001	-21.4453	-6.6347
	F3	-5.95000	2.25011	.135	-13.3553	1.4553
	F5	6.31333	2.25011	.106	-1.0920	13.7186
F5	F1	-17.40000*	2.25011	.000	-24.8053	-9.9947
	F2	-20.35333*	2.25011	.000	-27.7586	-12.9480
	F3	-12.26333*	2.25011	.002	-19.6686	-4.8580
	F4	-6.31333	2.25011	.106	-13.7186	1.0920

*. The mean difference is significant at the 0.05 level.

Homogeneous subset L* of muffin incorporated with breadfruit flour

Tukey HSD

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
F5	3	37.6467			
F4	3	41.5100	41.5100		
F3	3		44.3867		
F2	3			55.1467	
F1	3				73.1567
Sig.		.358	.616	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous subset a* of muffin incorporated with breadfruit flour

Tukey HSD

Sample	N	Subset for alpha = 0.05		
		1	2	3
F1	3	3.7533		
F5	3		11.0200	
F2	3		13.6367	13.6367
F4	3		13.6567	13.6567
F3	3			17.3033
Sig.		1.000	.590	.302

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous subset b* of muffin incorporated with breadfruit flour

Tukey HSD

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
F5	3	19.1433			
F4	3	25.4567	25.4567		
F3	3		31.4067	31.4067	
F1	3			36.5433	36.5433
F2	3				39.4967
		.106	.135	.227	.690

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Texture profile analysis of hardness in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	115548084.400	4	28887021.100	3.011	.072
Within Groups	95949193.333	10	9594919.333		
Total	211497277.733	14			

Texture profile analysis of resilience in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.012	4	.003	30.933	.000
Within Groups	.001	10	.000		
Total	.013	14			

Texture profile analysis of cohesiveness in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.068	4	.017	8.886	.003
Within Groups	.019	10	.002		
Total	.087	14			

Texture profile analysis of springiness in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.143	4	.286	1.760	.213
Within Groups	1.623	10	.162		
Total	2.766	14			

Texture profile analysis of chewiness in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	123665.404	4	30916.351	7.143	.006
Within Groups	43280.033	10	4328.003		
Total	166945.437	14			

Multiple comparison of hardness

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	2121.66667	2529.15260	.912	-6201.9823	10445.3156
	F3	-4459.00000	2529.15260	.442	-12782.6490	3864.6490
	F4	-5378.00000	2529.15260	.281	-13701.6490	2945.6490
	F5	-2265.33333	2529.15260	.892	-10588.9823	6058.3156
F2	F1	-2121.66667	2529.15260	.912	-10445.3156	6201.9823
	F3	-6580.66667	2529.15260	.143	-14904.3156	1742.9823
	F4	-7499.66667	2529.15260	.083	-15823.3156	823.9823
	F5	-4387.00000	2529.15260	.457	-12710.6490	3936.6490
F3	F1	4459.00000	2529.15260	.442	-3864.6490	12782.6490
	F2	6580.66667	2529.15260	.143	-1742.9823	14904.3156
	F4	-919.00000	2529.15260	.996	-9242.6490	7404.6490
	F5	2193.66667	2529.15260	.902	-6129.9823	10517.3156
F4	F1	5378.00000	2529.15260	.281	-2945.6490	13701.6490
	F2	7499.66667	2529.15260	.083	-823.9823	15823.3156
	F3	919.00000	2529.15260	.996	-7404.6490	9242.6490
	F5	3112.66667	2529.15260	.735	-5210.9823	11436.3156
F5	F1	2265.33333	2529.15260	.892	-6058.3156	10588.9823
	F2	4387.00000	2529.15260	.457	-3936.6490	12710.6490
	F3	-2193.66667	2529.15260	.902	-10517.3156	6129.9823
	F4	-3112.66667	2529.15260	.735	-11436.3156	5210.9823

*. The mean difference is significant at the 0.05 level.

Multiple comparison of resilience

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	-.01000	.00816	.738	-.0369	.0169
	F3	-.00667	.00816	.920	-.0335	.0202
	F4	.02667	.00816	.052	-.0002	.0535
	F5	.06667*	.00816	.000	.0398	.0935
F2	F1	.01000	.00816	.738	-.0169	.0369
	F3	.00333	.00816	.993	-.0235	.0302
	F4	.03667*	.00816	.008	.0098	.0635
	F5	.07667*	.00816	.000	.0498	.1035
F3	F1	.00667	.00816	.920	-.0202	.0335
	F2	-.00333	.00816	.993	-.0302	.0235
	F4	.03333*	.00816	.015	.0065	.0602
	F5	.07333*	.00816	.000	.0465	.1002
F4	F1	-.02667	.00816	.052	-.0535	.0002
	F2	-.03667*	.00816	.008	-.0635	-.0098
	F3	-.03333*	.00816	.015	-.0602	-.0065
	F5	.04000*	.00816	.004	.0131	.0669
F5	F1	-.06667*	.00816	.000	-.0935	-.0398
	F2	-.07667*	.00816	.000	-.1035	-.0498
	F3	-.07333*	.00816	.000	-.1002	-.0465
	F4	-.04000*	.00816	.004	-.0669	-.0131

*. The mean difference is significant at the 0.05 level.

Multiple comparison of cohesiveness

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	-.00667	.03565	1.000	-.1240	.1107
	F3	-.05333	.03565	.587	-.1707	.0640
	F4	-.03667	.03565	.837	-.1540	.0807
	F5	.13667*	.03565	.022	.0193	.2540
F2	F1	.00667	.03565	1.000	-.1107	.1240
	F3	-.04667	.03565	.692	-.1640	.0707
	F4	-.03000	.03565	.911	-.1473	.0873
	F5	.14333*	.03565	.016	.0260	.2607
F3	F1	.05333	.03565	.587	-.0640	.1707
	F2	.04667	.03565	.692	-.0707	.1640
	F4	.01667	.03565	.989	-.1007	.1340
	F5	.19000*	.03565	.002	.0727	.3073
F4	F1	.03667	.03565	.837	-.0807	.1540
	F2	.03000	.03565	.911	-.0873	.1473
	F3	-.01667	.03565	.989	-.1340	.1007
	F5	.17333*	.03565	.005	.0560	.2907
F5	F1	-.13667*	.03565	.022	-.2540	-.0193
	F2	-.14333*	.03565	.016	-.2607	-.0260
	F3	-.19000*	.03565	.002	-.3073	-.0727
	F4	-.17333*	.03565	.005	-.2907	-.0560

*. The mean difference is significant at the 0.05 level.

Multiple comparison of springiness

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	-.34667	.32894	.825	-1.4292	.7359
	F3	-.00333	.32894	1.000	-1.0859	1.0792
	F4	.11000	.32894	.997	-.9726	1.1926
	F5	.51333	.32894	.551	-.5692	1.5959
F2	F1	.34667	.32894	.825	-.7359	1.4292
	F3	.34333	.32894	.830	-.7392	1.4259
	F4	.45667	.32894	.648	-.6259	1.5392
	F5	.86000	.32894	.141	-.2226	1.9426
F3	F1	.00333	.32894	1.000	-1.0792	1.0859
	F2	-.34333	.32894	.830	-1.4259	.7392
	F4	.11333	.32894	.996	-.9692	1.1959
	F5	.51667	.32894	.545	-.5659	1.5992
F4	F1	-.11000	.32894	.997	-1.1926	.9726
	F2	-.45667	.32894	.648	-1.5392	.6259
	F3	-.11333	.32894	.996	-1.1959	.9692
	F5	.40333	.32894	.738	-.6792	1.4859
F5	F1	-.51333	.32894	.551	-1.5959	.5692
	F2	-.86000	.32894	.141	-1.9426	.2226
	F3	-.51667	.32894	.545	-1.5992	.5659
	F4	-.40333	.32894	.738	-1.4859	.6792

*. The mean difference is significant at the 0.05 level.

Multiple comparison of chewiness

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	29.50000	53.71532	.980	-147.2815	206.2815
	F3	-167.23333	53.71532	.066	-344.0149	9.5482
	F4	-159.40000	53.71532	.082	-336.1815	17.3815
	F5	32.06667	53.71532	.972	-144.7149	208.8482
F2	F1	-29.50000	53.71532	.980	-206.2815	147.2815
	F3	-196.73333*	53.71532	.028	-373.5149	-19.9518
	F4	-188.90000*	53.71532	.035	-365.6815	-12.1185
	F5	2.56667	53.71532	1.000	-174.2149	179.3482
F3	F1	167.23333	53.71532	.066	-9.5482	344.0149
	F2	196.73333*	53.71532	.028	19.9518	373.5149
	F4	7.83333	53.71532	1.000	-168.9482	184.6149
	F5	199.30000*	53.71532	.026	22.5185	376.0815
F4	F1	159.40000	53.71532	.082	-17.3815	336.1815
	F2	188.90000*	53.71532	.035	12.1185	365.6815
	F3	-7.83333	53.71532	1.000	-184.6149	168.9482
	F5	191.46667*	53.71532	.033	14.6851	368.2482
F5	F1	-32.06667	53.71532	.972	-208.8482	144.7149
	F2	-2.56667	53.71532	1.000	-179.3482	174.2149
	F3	-199.30000*	53.71532	.026	-376.0815	-22.5185
	F4	-191.46667*	53.71532	.033	-368.2482	-14.6851

*. The mean difference is significant at the 0.05 level.

Homogeneous subset of hardness

Tukey HSD

Sample	N	Subset for alpha = 0.05
		1
F2	3	2744.6667
F1 (Control)	3	4866.3333
F5	3	7131.6667
F3	3	9325.3333
F4	3	10244.3333
Sig.		.083

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous subset of resilience

Tukey HSD

Sample	N	Subset for alpha = 0.05		
		1	2	3
F5	3	.0133		
F4	3		.0533	
F1 (Control)	3		.0800	.0800
F3	3			.0867
F2	3			.0900
Sig.		1.000	.052	.738

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous subset of cohesiveness

Tukey HSD

Sample	N	Subset for alpha = 0.05	
		1	2
F5	3	.0933	
F1 (Control)	3		.2367
F2	3		.2367
F4	3		.2667
F3	3		.2833
Sig.		1.000	.587

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous subset of springiness

Tukey HSD

Sample	N	Subset for alpha = 0.05
		1
F5	3	.6133
F4	3	1.0167
F1 (Control)	3	1.1267
F3	3	1.1300
F2	3	1.4733
Sig.		.141

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous subset of chewiness

Tukey HSD

Sample	N	Subset for alpha = 0.05	
		1	2
F5	3	88.8333	
F2	3	91.4000	
F1 (Control)	3	120.9000	120.9000
F4	3		280.3000
F3	3		288.1333
Sig.			.066

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Proximate analysis of moisture content in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.629	2	1.314	1.065	.402
Within Groups	7.407	6	1.234		
Total	10.036	8			

Proximate analysis of ash content in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	37.869	2	18.934	5.197	.049
Within Groups	21.860	6	3.643		
Total	59.729	8			

Proximate analysis of fat content in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4234.269	2	2117.134	99.718	.000
Within Groups	127.387	6	21.231		
Total	4361.656	8			

Proximate analysis of protein content in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.447	2	5.223	2.438	.168
Within Groups	12.853	6	2.142		
Total	23.300	8			

Proximate analysis of fiber content in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	109.502	2	54.751	239.204	.000
Within Groups	1.373	6	.229		
Total	110.876	8			

Carbohydrate content in One-way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1520.828	2	760.414	41.223	.000
Within Groups	110.677	6	18.446		
Total	1631.505	8			

Multiple comparison of moisture content

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	1.26667	.90717	.400	-1.5168	4.0501
	F5	.30000	.90717	.942	-2.4835	3.0835
F2	F1	-1.26667	.90717	.400	-4.0501	1.5168
	F5	-.96667	.90717	.567	-3.7501	1.8168
F5	F1	-.30000	.90717	.942	-3.0835	2.4835
	F2	.96667	.90717	.567	-1.8168	3.7501

*. The mean difference is significant at the 0.05 level.

Multiple comparison of ash content

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower bound	Upper bound
F1	F2	4.63333	1.55849	.056	-.1485	9.4152
	F5	4.00000	1.55849	.094	-.7819	8.7819
F2	F1	-4.63333	1.55849	.056	-9.4152	.1485
	F5	-.63333	1.55849	.914	-5.4152	4.1485
F5	F1	-4.00000	1.55849	.094	-8.7819	.7819
	F2	.63333	1.55849	.914	-4.1485	5.4152

*. The mean difference is significant at the 0.05 level.

Multiple comparison of fat content

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower bound	Upper bound
F1	F2	-8.03333	3.76219	.163	-19.5768	3.5101
	F5	-49.50000*	3.76219	.000	-61.0434	-37.9566
F2	F1	8.03333	3.76219	.163	-3.5101	19.5768
	F5	-41.46667*	3.76219	.000	-53.0101	-29.9232
F5	F1	49.50000*	3.76219	.000	37.9566	61.0434
	F2	41.46667*	3.76219	.000	29.9232	53.0101

*. The mean difference is significant at the 0.05 level.

Multiple comparison of protein content

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower bound	Upper bound
F1	F2	2.63333	1.19505	.149	-1.0334	6.3001
	F5	1.46667	1.19505	.481	-2.2001	5.1334
F2	F1	-2.63333	1.19505	.149	-6.3001	1.0334
	F5	-1.16667	1.19505	.617	-4.8334	2.5001
F5	F1	-1.46667	1.19505	.481	-5.1334	2.2001
	F2	1.16667	1.19505	.617	-2.5001	4.8334

*. The mean difference is significant at the 0.05 level.

Multiple comparison of fiber content

Tukey HSD

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower bound	Upper bound
F1	F2	-2.53333*	.39063	.002	-3.7319	-1.3348
	F5	-8.33333*	.39063	.000	-9.5319	-7.1348
F2	F1	2.53333*	.39063	.002	1.3348	3.7319
	F5	-5.80000*	.39063	.000	-6.9986	-4.6014
F5	F1	8.33333*	.39063	.000	7.1348	9.5319
	F2	5.80000*	.39063	.000	4.6014	6.9986

*. The mean difference is significant at the 0.05 level.

Multiple comparison of carbohydrate content

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F1	F2	-.3822409	3.5067685	.993	-11.141969	10.377488
	F5	27.3824949*	3.5067685	.001	16.622766	38.142224
F2	F1	.3822409	3.5067685	.993	-10.377488	11.141969
	F5	27.7647358*	3.5067685	.001	17.005007	38.524464
F5	F1	-27.3824949*	3.5067685	.001	-38.142224	-16.622766
	F2	-27.7647358*	3.5067685	.001	-38.524464	-17.005007

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets of moisture content

Tukey HSD

Sample	N	Subset for alpha = 0.05
		1
F2	3	31.9333
F5	3	32.9000
F1 (Control)	3	33.2000
Sig.		.400

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous Subsets of ash content

Tukey HSD

Sample	N	Subset for alpha = 0.05
		1
F2	3	12.9333
F5	3	13.5667
F1 (Control)	3	17.5667
Sig.		.056

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous Subsets of fat content

Tukey HSD

Sample	N	Subset for alpha = 0.05	
		1	2
F1 (Control)	3	45.0000	
F2	3	53.0333	
F5	3		94.5000
Sig.		.163	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous Subsets of protein content

Tukey HSD

Sample	N	Subset for alpha = 0.05
		1
F2	3	14.7000
F5	3	15.8667
F1 (Control)	3	17.3333
Sig.		.149

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous Subsets of fiber

Tukey HSD

Sample	N	Subset for alpha = 0.05		
		1	3	3
F1 (Control)	3	2.0000		
F2	3		4.5333	
F5	3			10.3333
Sig.		1.000		

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous subsets for carbohydrate content

Tukey HSD

Sample	N	Subset for alpha = 0.05	
		1	2
F5	3	23.078455	
F1	3		50.460950
F2	3		50.843191
Sig.		1.000	.993

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

APPENDIX B: TEXTURE PROFILE ANALYSIS OUTPUT

TexturePro CT V1.7 Build 28 | **Brookfield Engineering Labs. Inc.**

DATA REPORT

Sample Description

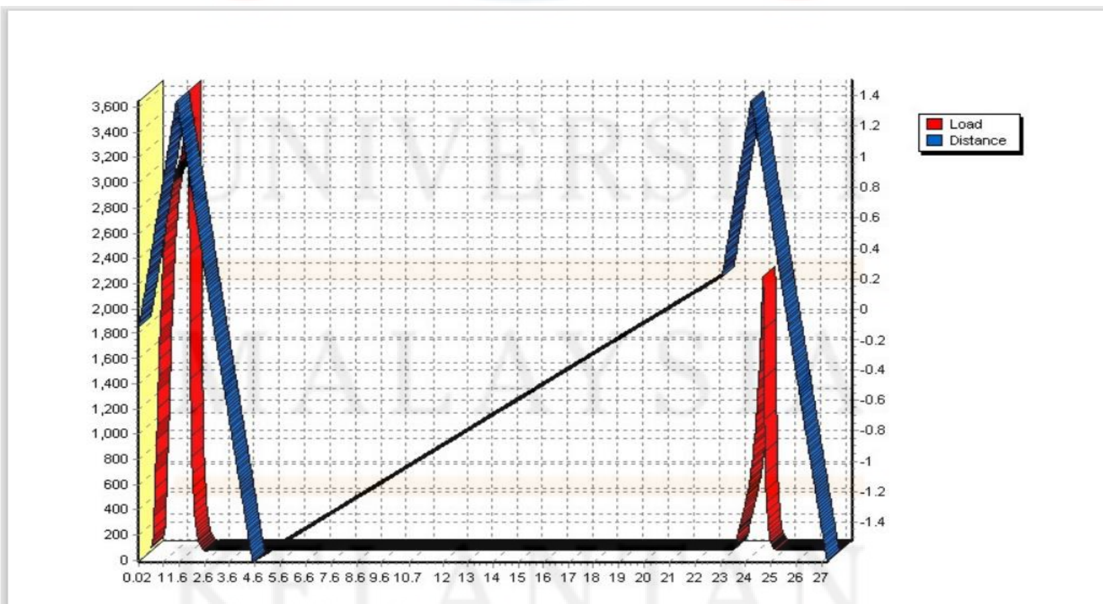
Product Name:	Breadfruit Muffin f1	**Note:**	
Batch Name:	one		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000	cm	
Width:	0.000	cm	
Depth:	0.000	cm	

Test Method

Test Date:	23/12/2021		**Test Time:**	10:24:02	
Test Type:	TPA		**Recovery Time:**	0	s
Target:	15.00	cm	**Same Trigger:**	True	
Hold Time:	0	s	**Pretest Speed:**	1.00	mm/s
Trigger Load:	5	g	**Data Rate:**	50.00	points/sec
Test Speed:	10.00	mm/s	**Probe:**	TA4/1000;	
Return Speed:	10	mm/s	**Fixture:**	TA-MTP	
# of Cycles:	2.0		**Load Cell:**	10000g	

Results

Hardness Cycle 1:	3645.00	g
Resilience:	0.08	
Hardness Cycle 2:	2176.00	g
Cohesiveness:	0.22	
Springiness:	1.15	cm
Chewiness:	90.90	mJ



TexturePro CT V1.7 Build 28 Brookfield Engineering Labs. Inc.

DATA REPORT

Sample Description

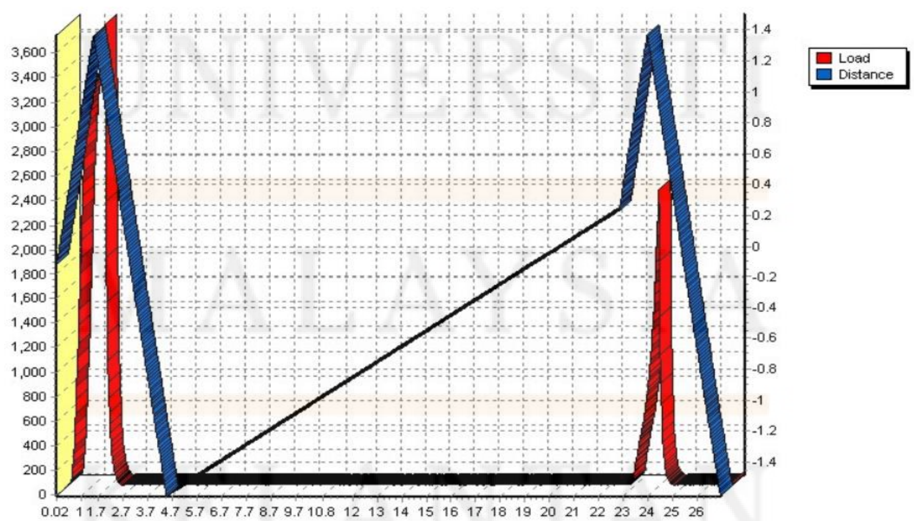
Product Name:	Breadfruit Muffin f1	**Note:**	
Batch Name:	two		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021	**Test Time:**	10:28:54
Test Type:	TPA	**Recovery Time:**	0 s
Target:	15.00 cm	**Same Trigger:**	True
Hold Time:	0 s	**Pretest Speed:**	1.00 mm/s
Trigger Load:	5 g	**Data Rate:**	50.00 points/sec
Test Speed:	10.00 mm/s	**Probe:**	TA4/1000;
Return Speed:	10 mm/s	**Fixture:**	TA-MTP
# of Cycles:	2.0	**Load Cell:**	10000g

Results

Hardness Cycle 1:	3744.00	g
Resilience:	0.09	
Hardness Cycle 2:	2406.00	g
Cohesiveness:	0.26	
Springiness:	1.12	cm
Chewiness:	105.50	mJ



TexturePro CT V1.7 Build 28 **Brookfield Engineering Labs. Inc.**

DATA REPORT

Sample Description

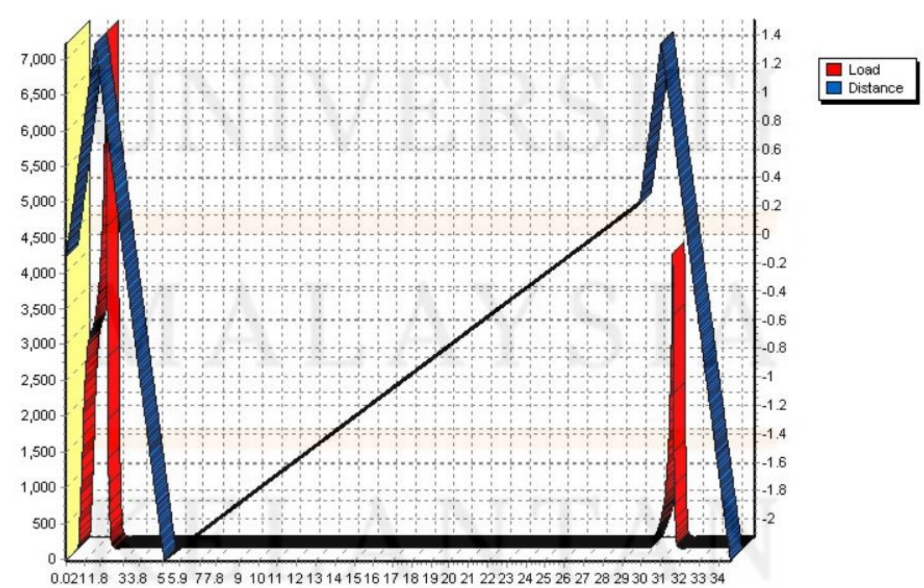
Product Name:	Breadfruit Muffin f1	**Note:**	
Batch Name:	three		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021	**Test Time:**	10:32:03
Test Type:	TPA	**Recovery Time:**	0 s
Target:	15.00 cm	**Same Trigger:**	True
Hold Time:	0 s	**Pretest Speed:**	1.00 mm/s
Trigger Load:	5 g	**Data Rate:**	50.00 points/sec
Test Speed:	10.00 mm/s	**Probe:**	TA4/1000;
Return Speed:	10 mm/s	**Fixture:**	TA-MTP
# of Cycles:	2.0	**Load Cell:**	10000g

Results

Hardness Cycle 1:	7210.00	g
Resilience:	0.07	
Hardness Cycle 2:	4123.00	g
Cohesiveness:	0.21	
Springiness:	1.11	cm
Chewiness:	166.30	mJ



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DATA REPORT

Sample Description

Product Name: Breadfruit Muffin F2

Note:

Batch Name: One

Sample: 1

Dimensions:

Shape: Block

Length: 0.000 cm

Width: 0.000 cm

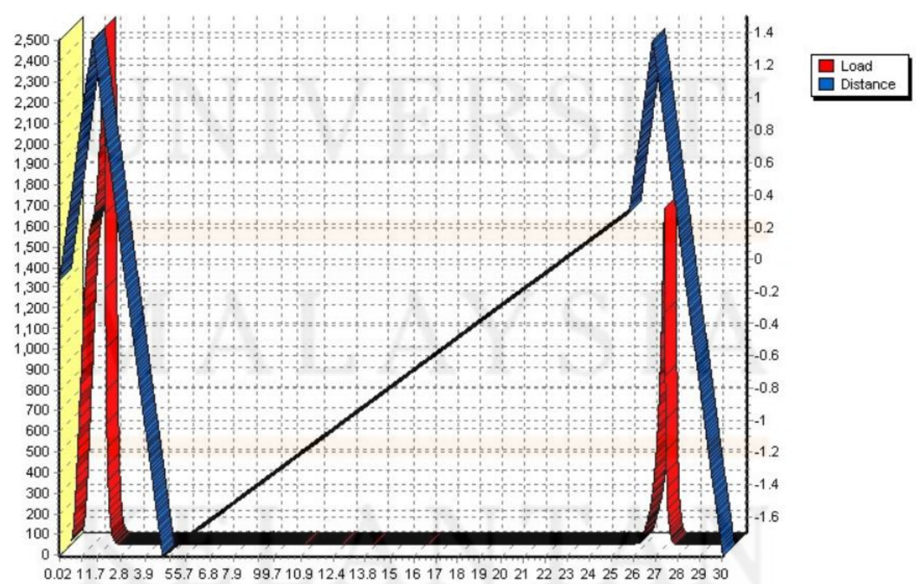
Depth: 0.000 cm

Test Method

Test Date:	23/12/2021	**Test Time:**	11:25:31
Test Type:	TPA	**Recovery Time:**	0 s
Target:	15.00 cm	**Same Trigger:**	True
Hold Time:	0 s	**Pretest Speed:**	1.00 mm/s
Trigger Load:	5 g	**Data Rate:**	50.00 points/sec
Test Speed:	10.00 mm/s	**Probe:**	TA4/1000;
Return Speed:	10 mm/s	**Fixture:**	TA-MTP
# of Cycles:	2.0	**Load Cell:**	10000g

Results

Hardness Cycle 1:	2503.00	g
Resilience:	0.09	
Hardness Cycle 2:	1632.00	g
Cohesiveness:	0.24	
Springiness:	1.06	cm
Chewiness:	63.50	mJ



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DATA REPORT

Sample Description

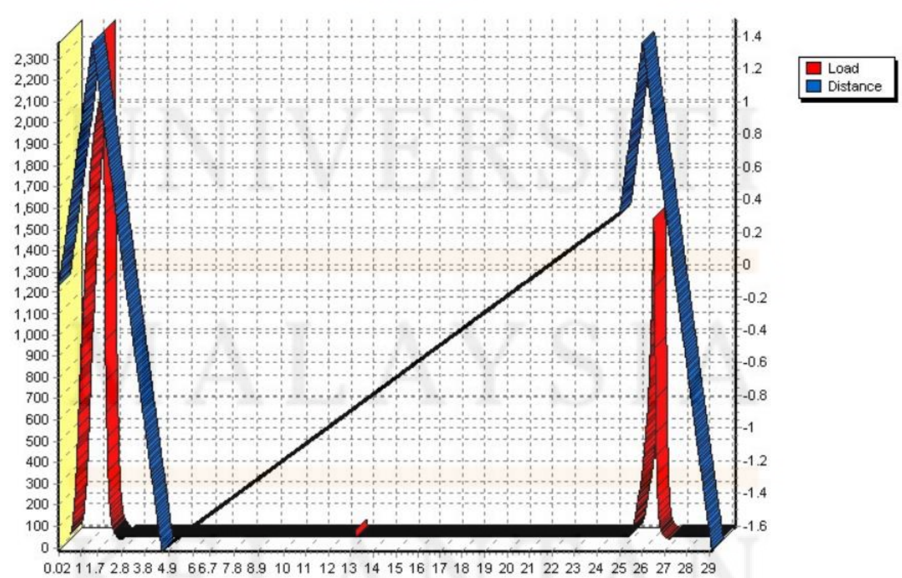
Product Name:	Breadfruit Muffin F2	Note:	
Batch Name:	Two		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021	Test Time:	11:30:36
Test Type:	TPA	Recovery Time:	0 s
Target:	15.00 cm	Same Trigger:	True
Hold Time:	0 s	Pretest Speed:	1.00 mm/s
Trigger Load:	5 g	Data Rate:	50.00 points/sec
Test Speed:	10.00 mm/s	Probe:	TA4/1000;
Return Speed:	10 mm/s	Fixture:	TA-MTP
# of Cycles:	2.0	Load Cell:	10000g

Results

Hardness Cycle 1:	2376.00	g
Resilience:	0.09	
Hardness Cycle 2:	1497.00	g
Cohesiveness:	0.24	
Springiness:	2.29	cm
Chewiness:	128.40	mJ



TexturePro CT V1.7 Build 28 **Brookfield Engineering Labs. Inc.**

DATA REPORT

Sample Description

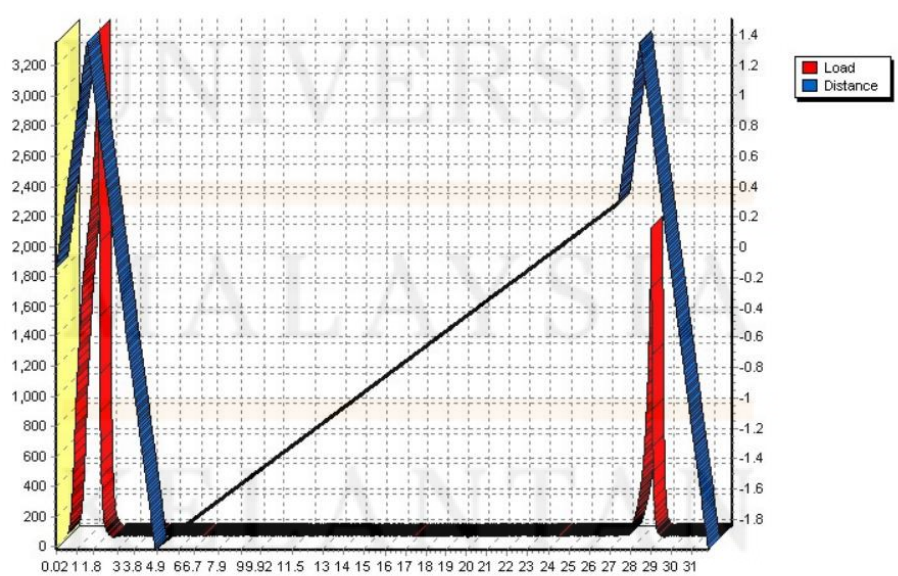
Product Name:	Breadfruit Muffin F2	**Note:**	
Batch Name:	Three		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021		**Test Time:**	11:33:26	
Test Type:	TPA		**Recovery Time:**	0	s
Target:	15.00	cm	**Same Trigger:**	True	
Hold Time:	0	s	**Pretest Speed:**	1.00	mm/s
Trigger Load:	5	g	**Data Rate:**	50.00	points/sec
Test Speed:	10.00	mm/s	**Probe:**	TA4/1000;	
Return Speed:	10	mm/s	**Fixture:**	TA-MTP	
# of Cycles:	2.0		**Load Cell:**	10000g	

Results

Hardness Cycle 1:	3355.00	g
Resilience:	0.09	
Hardness Cycle 2:	2047.00	g
Cohesiveness:	0.23	
Springiness:	1.07	cm
Chewiness:	82.30	mJ



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DATA REPORT

Sample Description

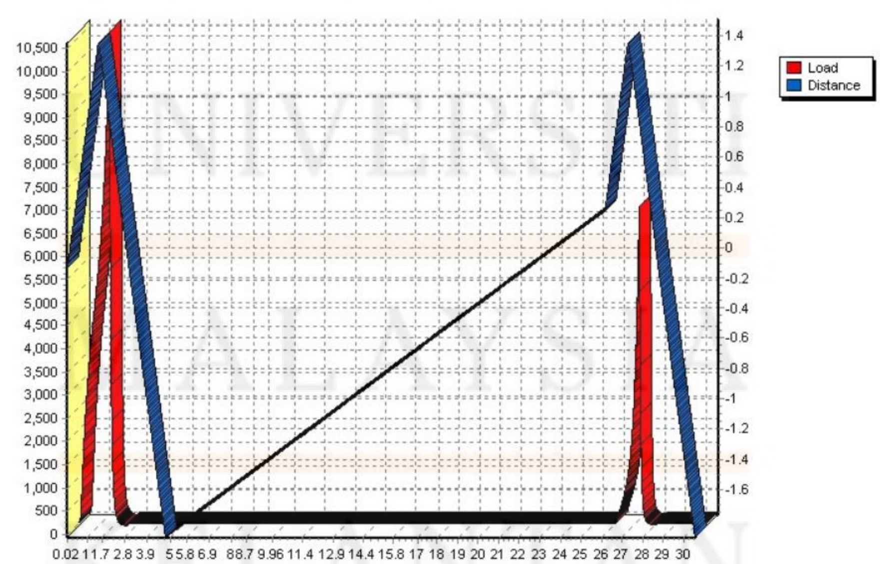
Product Name:	BReadfruit Muffin F3	Note:	
Batch Name:	One		
Sample:	2		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021	Test Time:	12:42:41
Test Type:	TPA	Recovery Time:	0 s
Target:	15.00 cm	Same Trigger:	True
Hold Time:	0 s	Pretest Speed:	1.00 mm/s
Trigger Load:	5 g	Data Rate:	50.00 points/sec
Test Speed:	10.00 mm/s	Probe:	TA4/1000;
Return Speed:	10 mm/s	Fixture:	TA-MTP
# of Cycles:	2.0	Load Cell:	10000g

Results

Hardness Cycle 1:	10608.00	g
Resilience:	0.08	
Hardness Cycle 2:	6833.00	g
Cohesiveness:	0.27	
Springiness:	1.11	cm
Chewiness:	307.00	mJ



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DATA REPORT

Sample Description

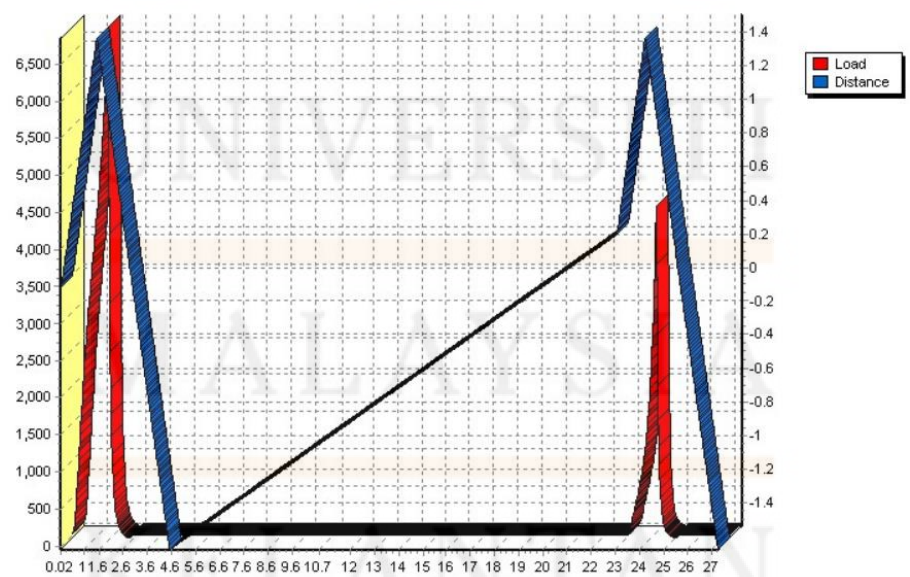
Product Name:	BReadfruit Muffin F3	Note:	
Batch Name:	Two		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021		Test Time:	12:53:58	
Test Type:	TPA		Recovery Time:	0	s
Target:	15.00	cm	Same Trigger:	True	
Hold Time:	0	s	Pretest Speed:	1.00	mm/s
Trigger Load:	5	g	Data Rate:	50.00	points/sec
Test Speed:	10.00	mm/s	Probe:	TA4/1000;	
Return Speed:	10	mm/s	Fixture:	TA-MTP	
# of Cycles:	2.0		Load Cell:	10000g	

Results

Hardness Cycle 1:	6842.00	g
Resilience:	0.10	
Hardness Cycle 2:	4428.00	g
Cohesiveness:	0.30	
Springiness:	1.15	cm
Chewiness:	234.00	mJ



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DATA REPORT

Sample Description

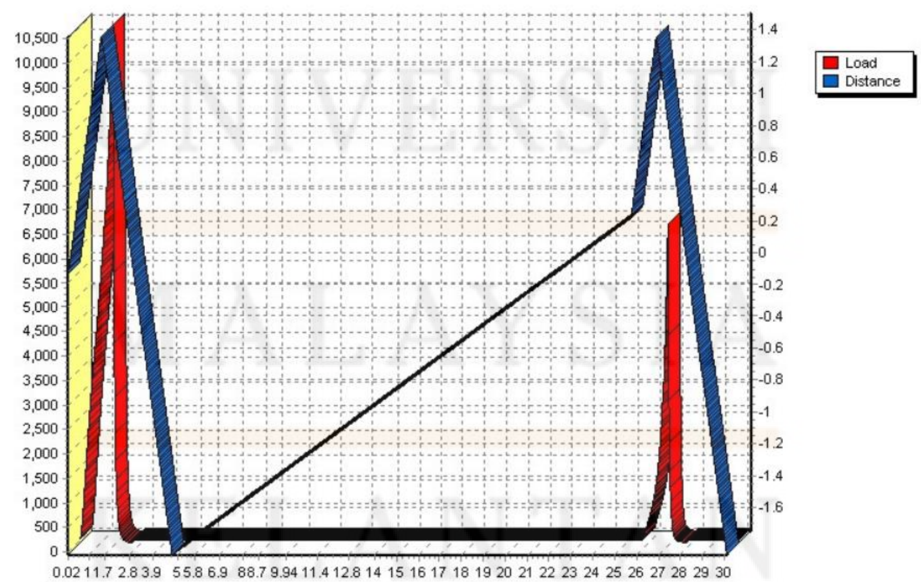
Product Name:	BReadfruit Muffin F3	Note:	
Batch Name:	One		
Sample:	2		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021	Test Time:	12:57:20
Test Type:	TPA	Recovery Time:	0 s
Target:	15.00 cm	Same Trigger:	True
Hold Time:	0 s	Pretest Speed:	1.00 mm/s
Trigger Load:	5 g	Data Rate:	50.00 points/sec
Test Speed:	10.00 mm/s	Probe:	TA4/1000;
Return Speed:	10 mm/s	Fixture:	TA-MTP
# of Cycles:	2.0	Load Cell:	10000g

Results

Hardness Cycle 1:	10526.00	g
Resilience:	0.08	
Hardness Cycle 2:	6469.00	g
Cohesiveness:	0.28	
Springiness:	1.13	cm
Chewiness:	323.40	mJ



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DATA REPORT

Sample Description

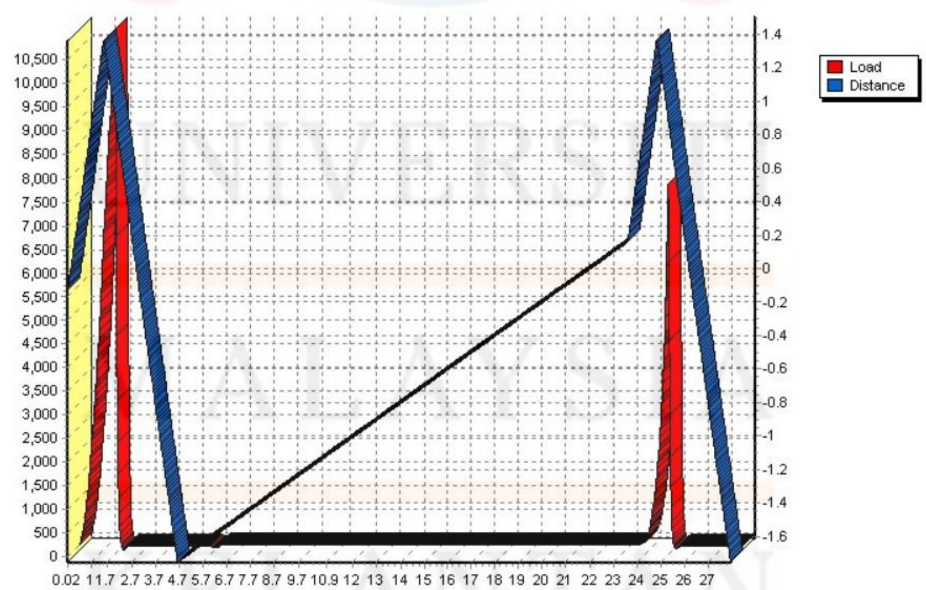
Product Name:	Breadfruit Muffin F4	Note:	
Batch Name:	One		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021	Test Time:	1:01:56 PM
Test Type:	TPA	Recovery Time:	0 s
Target:	15.00 cm	Same Trigger:	True
Hold Time:	0 s	Pretest Speed:	1.00 mm/s
Trigger Load:	5 g	Data Rate:	50.00 points/sec
Test Speed:	10.00 mm/s	Probe:	TA4/1000;
Return Speed:	10 mm/s	Fixture:	TA-MTP
# of Cycles:	2.0	Load Cell:	10000g

Results

Hardness Cycle 1:	10898.00	g
Resilience:	0.06	
Hardness Cycle 2:	7627.00	g
Cohesiveness:	0.31	
Springiness:	1.20	cm
Chewiness:	399.80	mJ



TexturePro CT V1.7 Build 28 Brookfield Engineering Labs. Inc.

DATA REPORT

Sample Description

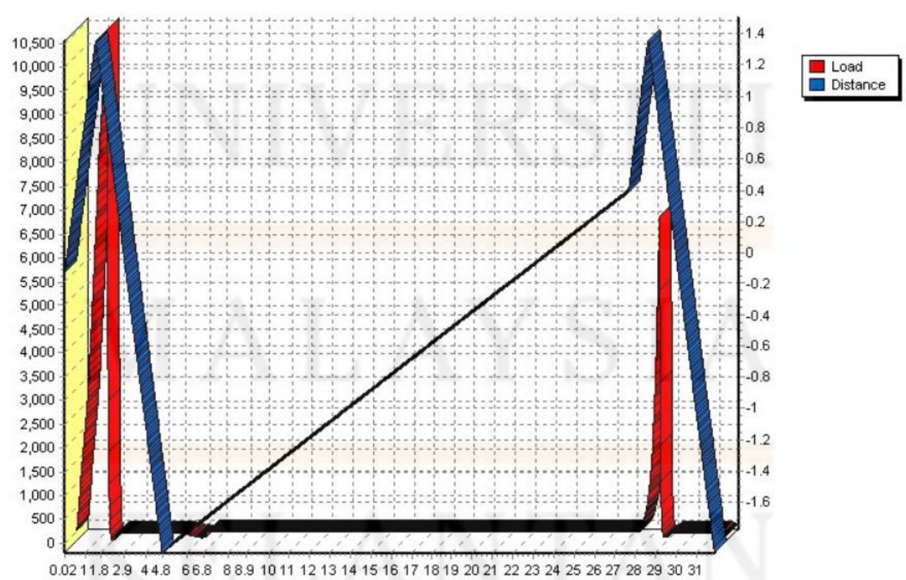
Product Name:	Breadfruit Muffin F4	**Note:**	
Batch Name:	Two		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021		**Test Time:**	1:21:16 PM	
Test Type:	TPA		**Recovery Time:**	0	s
Target:	15.00	cm	**Same Trigger:**	True	
Hold Time:	0	s	**Pretest Speed:**	1.00	mm/s
Trigger Load:	5	g	**Data Rate:**	50.00	points/sec
Test Speed:	10.00	mm/s	**Probe:**	TA4/1000;	
Return Speed:	10	mm/s	**Fixture:**	TA-MTP	
# of Cycles:	2.0		**Load Cell:**	10000g	

Results

Hardness Cycle 1:	10552.00	g
Resilience:	0.04	
Hardness Cycle 2:	6623.00	g
Cohesiveness:	0.22	
Springiness:	0.95	cm
Chewiness:	220.30	mJ



TexturePro CT V1.7 Build 28 | Brookfield Engineering Labs. Inc.

DATA REPORT

Sample Description

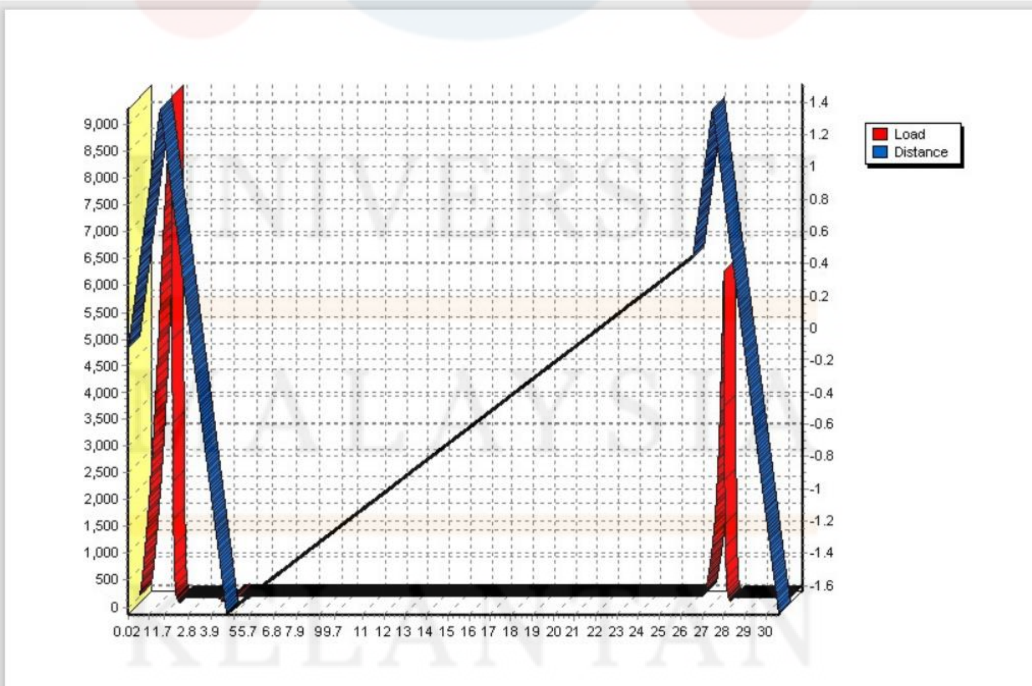
Product Name:	Breadfruit Muffin F4	Note:	
Batch Name:	Three		
Sample:	1		
Dimensions:			
Shape:	Block		
Length:	0.000 cm		
Width:	0.000 cm		
Depth:	0.000 cm		

Test Method

Test Date:	23/12/2021		Test Time:	1:24:08 PM	
Test Type:	TPA		Recovery Time:	0	s
Target:	15.00	cm	Same Trigger:	True	
Hold Time:	0	s	Pretest Speed:	1.00	mm/s
Trigger Load:	5	g	Data Rate:	50.00	points/sec
Test Speed:	10.00	mm/s	Probe:	TA4/1000;	
Return Speed:	10	mm/s	Fixture:	TA-MTP	
# of Cycles:	2.0		Load Cell:	10000g	

Results

Hardness Cycle 1:	9283.00	g
Resilience:	0.06	
Hardness Cycle 2:	6069.00	g
Cohesiveness:	0.27	
Springiness:	0.90	cm
Chewiness:	220.80	mJ



TexturePro CT V1.7 Build 28 **Brookfield Engineering Labs. Inc.**

DATA REPORT

Sample Description

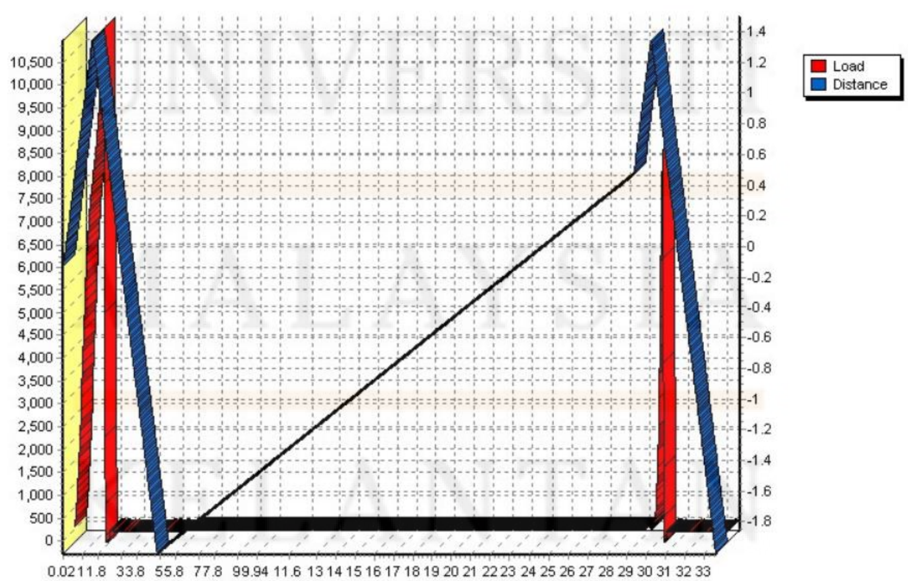
Product Name: Breadfruit Muffin F5 **Note:**
Batch Name: One
Sample: 1
Dimensions:
Shape: Block
Length: 0.000 cm
Width: 0.000 cm
Depth: 0.000 cm

Test Method

Test Date:	23/12/2021	**Test Time:**	1:28:15 PM
Test Type:	TPA	**Recovery Time:**	0 s
Target:	15.00 cm	**Same Trigger:**	True
Hold Time:	0 s	**Pretest Speed:**	1.00 mm/s
Trigger Load:	5 g	**Data Rate:**	50.00 points/sec
Test Speed:	10.00 mm/s	**Probe:**	TA4/1000;
Return Speed:	10 mm/s	**Fixture:**	TA-MTP
# of Cycles:	2.0	**Load Cell:**	10000g

Results

Hardness Cycle 1:	10969.00	g
Resilience:	0.02	
Hardness Cycle 2:	8328.00	g
Cohesiveness:	0.14	
Springiness:	0.87	cm
Chewiness:	127.60	mJ



TexturePro CT V1.7 Build 28 **Brookfield Engineering Labs. Inc.**

DATA REPORT

Sample Description

Product Name:	Breadfruit Muffin F5
Batch Name:	Two
Sample:	1
Dimensions:	
Shape:	Block
Length:	0.000 cm
Width:	0.000 cm
Depth:	0.000 cm

Note:

Test Method

Test Date:	23/12/2021	**Test Time:**	1:32:45 PM
Test Type:	TPA	**Recovery Time:**	0 s
Target:	15.00 cm	**Same Trigger:**	True
Hold Time:	0 s	**Pretest Speed:**	1.00 mm/s
Trigger Load:	5 g	**Data Rate:**	50.00 points/sec
Test Speed:	10.00 mm/s	**Probe:**	TA4/1000;
Return Speed:	10 mm/s	**Fixture:**	TA-MTP
# of Cycles:	2.0	**Load Cell:**	10000g

Results

Hardness Cycle 1:	10426.00	g
Resilience:	0.02	
Hardness Cycle 2:	7556.00	g
Cohesiveness:	0.14	
Springiness:	0.97	cm
Chewiness:	138.90	mJ