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Characteristic of Analogue Jerky Made from Moringa Leaves (*Moringa oleivera* L) with the addition of Tapioca Flour

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Abstract. Moringa leaves are known as miracle leaves because it contains substances that are useful as nutrients and beneficial to health, which have not been optimally utilized. This study aimed to determine the effect of tapioca flour addition on the characteristics of analogue jerky of Moringa leaves. The study design used a completely randomized design (CRD) with 5 treatments, that was the addition of tapioca flour (A; 45 g, B; 50 g, C; 55 g, D; 60 g, and E; 65 g) with 3 replications. It was conducted in two stages. The first step is to determine the products that are well received by using sensory evaluations (score ≥ 3.60) The second was to analyse chemical characteristic of the products. Data from chemical observations were statistically analysed using ANOVA and continued with Duncan New Multiple Range Test (DMNRT) at a significance level of 5%. The results showed that the addition of tapioca flour produced analogue jerky with a value of ≥ 3.6 for colour, texture and taste, were the B, C and D treatment. From the statistically analysis showed there were significant differences of moisture content, fat content, protein content, calcium levels and crude fibre content between treatments B, C and D of analogue jerky, but there was no significant difference on the ash content of analogue jerky. B Product is the best product with a moisture content of 3.11 ± 0.19%, ash content of 0.94 ± 0.00%, fat content of 0.18 ± 0.02%, protein content of 8, 24 ± 0.01%, calcium levels 203.43 ± 0.03%, crude fibre content 0.42 ± 0.01%. No free fatty acids and number of peroxides were detected in the analogue jerky.
Keywords: Analogue Jerky, Moringa Leaves, Tapioca Flour, Chemical Characteristic, Sensory Analysis

1. Introduction

Moringa oleifera L is a plant that thrives in the tropics even in countries that have four seasons in the world [1]. Moringa plants were believed have high nutritional value and beneficial for health so get the nickname as the miracle tree, tree for life and amazing tree [2], all parts of the Moringa plants, especially the leaves are used as food. Most Indonesian people have processed Moringa leaves into several products such as clear vegetables, coconut milk, stir-fry and processed into the tea.

Moringa plant (*Moringa oleifera*) has the potential great as a source of nutrition, natural treatment and for cosmetics. All parts of the Moringa plant provide benefits both for food and non-food. As a plant which is rich in nutrients both macro and microorganisms are not only a source of nutrition for food products but also have an effect pharmacology. This is caused by height the content of bioactive compounds in plants Moringa. This potential provides opportunities for the pharmaceutical industry to make plants Moringa as an alternative treatment made from natural raw [3].

Shiriki et al. showed that moringa leaf flour contained 26.40% crude protein, 16.8% crude fiber, 3.30% crude fat and 8.50% ash content [4]. Moringa leaf also contains bioactive components. Siddhuraju et al. reported that the main major bioactive components found in leaves are phenolic compounds which are a group of flavonoids such as quercetin and kaempferol. Based on the results obtained, Moringa leaves are found as a potential source of natural antioxidants because of their apparent antioxidant activity [5].

The use of moringa leaf flour has also been tried as an additional ingredient in the production of sausages, the results showed that the addition of moringa leaf flour to mackerel fish sausages produces sausages that are preferred and meet the quality requirements of sausages with higher protein levels and low fat [6]. The same results have also been found in other studies that was the addition of Moringa leaves in the manufacture of "siomay" as additional food (PMT), the results showed that the addition of moringa leaves can increase protein levels of "siomay" [7]

Analogue jerky is artificial jerky made from non-meat raw materials. Called analogue jerky because of its shape which resembles beef jerky but does not use meat during processing. In this study, analogue jerky that will be processed using vegetable raw materials, namely Moringa leaves. The addition of supporting materials as fillers and binders is needed in order to produce products that resemble beef jerky. In making analogue jerky fillers and binders are needed so that the main ingredients can be formed into beef jerky. Binder is a material used in the food industry to bind water contained in a dough. One of the binding materials in food is tapioca flour. Tapioca besides functioning as a binder is also useful as a filler.

Tapioca is the result of the extraction of cassava starch (*Manihot esculenta* Crantz) which is widely used as fillers and adhesives in the food industry. Tapioca is a starch consisting mostly of amylopectin. The nature of amylopectin which can bind and fill the empty space due to cooking is the reason tapioca is chosen as a filler and binder of Moringa leaf jerky, but tapioca is also very easy to find in the market at an affordable price. In determining the formulation, the author uses trial and error method. By using the "trial and error" method, the addition of tapioca flour 45, 50, 55, 60 and 60 g to 100 g of Moringa leaf powder, produces analogue jerky which can be formed with an acceptable taste. This study aims to learn the effect of tapioca flour addition on the characteristics of beef jerky analogue and get the best products that can be accepted both organoleptically and physically and chemically.

2. Methods

2.1. Sources of materials

The main ingredient used in this study was *Moringa oleifera* L, taken in "Kelawi" village, Padang, West Sumatra. Tapioca flour and other seasonings such as onion, garlic, ginger, galangal, *kencur*, pepper, coriander, kaffir lime leaves, salt and eggs are obtained from the traditional market of "Bandar Buat", Padang, West Sumatra.

2.2 The Design

The method used in this study is a Completely Randomized Design (CRD) with 5 treatments and 3 replications. The treatment in this study was the amount of tapioca flour added in making analogous jerky on the total weight of the moringa leaf material. There were two steps in this study. The first step was to find the product that was accepted by panelist (score $\geq$ 3.6). The second step was to analyze the physical and chemical observation on the products. The physical and chemical data were statistically analyzed using analysis of variant, it was followed by the Duncan's News Multiple Range Test (DNMRT) at the 5% level.

The treatments of this study were the addition of tapioca flour on moringa leaf of 100 g as follows:

Treatment A = Addition of tapioca flour 45 g

Treatment B = addition of tapioca flour 50 g

Treatment C = addition of tapioca flour 55 g

Treatment D = Addition of tapioca flour 60 g
Treatment E = Addition of tapioca flour 65 g

2.3 The Process of Making Analogue Jerky.

Moringa leaves are separated from the stems and leaves that have yellowed or rotted. Moringa leaves are separated into 5 parts with 500 grams each, then washed thoroughly with water and drained. Moringa leaves that have been drained then boiled for 1 minute at 100 ^{0}C then drained. Moringa leaves are blended using a blender and mashed separately. Then the Moringa leaf powder is mixed with tapioca flour according to the treatment, and then mixed with crushed seasoning. Homogeneous dough is put into a container and flattened to a thickness of ± 0.3 cm. The dough is steamed for 5 minutes, then dried using an oven at 110 ^{0}C for 2.5 hours until the water content reaches 15-20%. The dried batter is cut 4x4 cm in size and a raw analogue jerky is formed. Raw analogue jerky is fried using disposable oil. Frying uses the deep fat frying method. Frying is done until the bubbles in the oil disappear, then the jerky is drained, and a fried analogue jerky is formed. Products are packed in PP (polypropylene) plastic in the form of standing pouch size 10 x 17 cm.

2.4 The Observation

Observation of moringa leaf raw materials including moisture content (Gravimetry method [8]), ash content (Gravimetry method, [8]) , calcium level [8], and protein content (Micro Kjedhal, [9]. For analogues jerky characteristics observed were sensory analysis, physical and chemical analysis. Sensory analysis consists of analysis of colour, texture and taste[10]. Physical analysis conducted is the measurement of yield and hardness test[11]. Chemical analysis includes moisture content, ash content, protein content, calcium level, fat content [8], crude fibre content[8] free fatty acid content [8] and peroxide number [9]

3. Results and Discussion

3.1 Analysis of Raw Material

Chemical observations made on Moringa leaves was moisture content, ash content, protein content, and calcium content. The results show in Table 1.

Table 1. The Chemical Composition of Moringa Leaves

Variable	Value
Moisture content (%)	79.67 ± 0.67
Ash content (%)	2.67 ± 0.12
Protein content (%)	9.23 ± 0.08
Calcium content (mg/100 g)	643.17 ± 0.03

Table 1 shows that the moisture content of Moringa leaves were 79.67%. The moisture content of fresh Moringa leaves is higher than the moisture content of fresh cassava leaves which was 77.93% it was also used as raw material for analogue jerky [12]. Moisture content in the material will affect the characteristics of the product produced.

The ash content of fresh Moringa leaf ash is 2.67%. Ash content describes the minerals in food. The ash content of fresh Moringa leaves is higher than the ash content of fresh cassava leaves that was 1.00% [12]. Ash content according to dry weight is 3.35% which is much lower than ash content of Moringa leaves according to dry weight in other study [13] which is 12.01%. This shows that the Moringa leaves used in our study have relatively low mineral content. Mineral content in analogue jerky products is needed as an added value for consumers.

Manggara and Shofi [14] stated that the minerals in fresh Moringa leaves consisted of Calcium (Ca) 603.77 mg / 100 g; Potassium (K) 264.96 mg / 100 g; Sulfuric (S) 23.45 mg / 100 g; Nickel (Ni) 22.60 mg / 100g; Iron (Fe) 20.49 mg / 100 g; and other minerals. Krisnadi [15] Fresh Moringa leaf protein content obtained was 9.23%. The protein content is higher than protein content of fresh cassava leaves according to that is equal to 6.7%. Moringa leaf protein consists of 8 essential amino

acids namely isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine and 10 non-essential amino acids namely alanine, arginine, aspartic acid, cystine, glutamic acid, glycine, histidine, serine, proline, tyrosine. Burlando et al. 2010 in [13] reported that moringa leaves also contain amino acids sulfur which are similar to amino acids contained in soybean seeds.

Calcium levels of fresh Moringa leaves were obtained at 643.17 mg / 100 g. The calcium level is higher than the calcium content of fresh moringa leaves which is 440.00 mg / 100 g [16]. Calcium is a part of minerals that are very useful for the body including growth of bones and teeth, so the body must get enough calcium every day. Moringa leaves also contain epigallocatechin-3-gallate. Sugianti [13] reported that dried Moringa leaves contain EGCG (epigallocatechin-3-gallate) as much as 0.76% and their antioxidant strength is 0.189 mg / ml. Cavet, et al 2011, in [17] showed that EGCG as the main polyphenol found in green tea which has been proven to have anti-inflammatory and antioxidant properties in several cell types.

3.2 Sensory Analysis of Product

Sensory analysis used 25 panelists to know the color, flavor, texture and taste. The value of hedonic ranking was 1 – 5; 1 = dislike extremely, 2 = dislike, 3 = rather like, 4 =like dan 5 = like extremely.

3.2.1 Color

Color is an indicator of appearance that can be seen directly by panellists on the Moringa leaf analogues jerky product. The results of color testing of analogues jerky products can be seen in Table 2. The table shows that the results of analogue jerky color analysis range between 3.3-4.0. and the criteria that are well accepted (3.7-4.0) are treatments A, B, C, and D. The color produced in the treatment is brown so that it resembles the color of beef jerky. The color of a product is produced from the color of the raw material used. The raw materials in making analogue jerky from Moringa leaves are green Moringa leaves and white tapioca. The analogues jerky produced is dark green to brownish. The resulting color is influenced by the presence of a maillard reaction between amino acids and reducing sugars from moringa and tapioca leaves and the frying process in processing. Winarno (2004) [18] states that the maillard reaction occurs due to the carbonate group of glucose reacting with the nucleophilic amino groups of proteins that produce a distinctive color (brown) and caused by melanoidin compounds, then for the dark green color produced is obtained from the chlorophyll content contained on Moringa leaves.

Table 2. Sensory Analysis of Analogues Jerky

Addition of Tapioca powder	Color	Flavor	Texture	Taste
A (45 g)	3.7 ± 0.75	3.8 ± 0.88	3.4 ± 0.82	3.4 ± 0.82
B (50 g)	4.4 ± 0.73	4.5 ± 0.78	4.6 ± 0.79	4,6 ± 0.79
C (55 g)	4.0 ± 0.68	3.8 ± 0.80	3.8 ± 0.93	3.8 ± 0.93
D (60 g)	3.9 ± 0,91	3.6 ± 0.91	3.6 ± 0.76	3.6 ± 0.76
E (65 g)	3.3 ± 0.98	3.4 ± 0.71	3.5 ± 0.71	3.5 ± 0.82

Note: The value of hedonic ranking was 1 – 5; 1 = dislike extremely, 2 = dislike, 3 = rather like, 4 = like dan 5 = like extremely

3.2.2 Flavor

Flavor is a very objective odor that is difficult to measure, because everyone has different sensitivity and preferences. The results of flavor testing of the analogue jerky products can be seen in Table 2. The value of analogue jerky flavor ranged from 3.4 to 3.8. Table 2. shows that the analogue jerky produced was well accepted by the panellists at the level of 3,6-3,8 found in treatments A, B, C and D. The flavor of the treatment originated from the spices added. The added spices are onion, garlic, pepper, coriander, ginger, galangal, *kencur*, orange leaf, and salt. The most striking aroma in jerky is the aroma of garlic and coriander. In garlic there is an allicin compound. Allicin is the main component that gives a distinctive odor to garlic, then in coriander there is linalool and kariandol (60-70%) which is a component of the oil to overcome it [12].

3.2.3 Texture

The value of analogue jerky texture ranged from 3.4-3.9. Table 2. shows that the analogue jerky produced received by the panellists in the level of liking (3,6-3,9) is found in treatments B, C and D. The texture in the treatment produces analogue jerky which is not too crispy but not too hard so that it resembles the texture of dried beef jerky. Texture is influenced by the water content contained in the ingredients. The less water content in food products will produce a dry product so that the resulting product is crispier.

3.2.4 Taste

The taste is a stimulus that is felt by the sense of taste and other stimuli such as touch and acceptance of the degree of heat by the mouth. In the mouth, food ingredients that have nerve stimulating properties under the skin of the face, tongue, and teeth will cause certain feelings [18]. The results of leaf analogue jerky taste testing can be seen in Table 2.

Table 2. shows that the analogue jerky produced was well acceptance by panellists (3,6-4,6) contained in the B, C and D. treatments. The resulting flavour was like beef jerky because it was added with spices in beef jerky processing, namely shallots, garlic, ginger, galangal, pepper, coriander and salt. A treatment was accepted by panellists at an ordinary level (3,4) because it had a slightly bitter taste. Bitter taste is caused by the content of tannin contained in Moringa leaves. Tannin compounds are astringent compounds which have a bitter taste from their polyphenol groups which can bind and precipitate proteins. The addition of salt and seasoning can disguise the bitter taste of the Moringa leaf analogue jerky. The addition of too much tapioca flour is also less liked by panellists because it produces harder jerky

3.3 Physical Analysis of Product

3.3.1 Yield

The yield is an important parameter to determine the economic value and effectiveness of a product or ingredient process. The percentage of yield is calculated based on the ratio of the final weight to the initial weight of the material. The higher the yield percentage, the higher the economic value of the product. The average value of analogue beef jerky yield from Moringa leaves can be seen in Table 3.

Table 3. The Physical Analysis of the Product

Addition of Tapioca powder	Yield (%) ± SD	Hardness (N/cm^2)
B (50 g)	52.03 ± 0.24 a	38.69 ± 3.38 a
C (55 g)	54.72 ± 0.28 b	49.03 ± 2.14 b
D (60 g)	56.50 ± 0.36 c	59.53 ± 4.41 c

Note: The number in the same column followed by unequal lowercase letter are significantly different at α = 5% by Duncan's Multiple Range Test (DMNRT)

Table 3 shows that the yield obtained on analogue jerky from Moringa leaves ranged from 52.03 to 56.50%. Table 3 shows that the more tapioca is added, the more analogue jerky is obtained.

Treatment D has the highest yield compared to other treatments. This is thought to be caused by: (1) the amount of tapioca added to each formula. The more flour is added, the heavier the product is produced; (2) The more flour, the more starch. The difference in the amount of starch in an ingredient is also related to the different water absorption capacity. The higher the starch, will also have an impact on the ability to absorb water, where in the frying process the water will come out and be replaced by oil. So that the more starch, the more oil is thought to be absorbed. Thus, it will affect product weight.

3.3.2 Hardness Test of Product

The value of violence is one of the parameters of consumer acceptance of a product. In addition to the organoleptic value, the level of violence is also dominant in consumers' judgment when consuming a

food. Hardness was tested using the CT3 Texture Analyzer tool. Hardness values can be seen in Table 3.

Based on Table 3. it is known that the value of analogue jerky hardness ranges from 38.69 to 59.53N / cm2. The highest level of hardness was in treatment D of 59.53 N / cm2, and the lowest was in treatment B of 38.69 N / cm2. The variance analysis showed that the difference of tapioca addition on the Moringa leaf jerky analogue had a significantly different effect on the level of α = 5% on the hardness value of the analogue jerky.

Moringa leaf jerky analogue was made with thickness 0.3 cm for all treatments. The level of hardness is influenced by the addition of different tapioca. According to Handayani (1987) in [19], if the starch is heated there will be a gelatinization process, the starch gel will undergo a dehydration process so that the gel forms a sturdy framework and causes the resulting texture to be hard. Then during the frying process, the water that is bound to the dough will evaporate due to the heating process to form small cavities that will affect the level of crispness of the analogue jerky. When compared with the level of hardness of beef jerky, the level of violence is not listed in SNI 2908-2013, but this level of violence needs to be known so that the analogue jerky product produced resembles dried beef jerky when consumed. Therefore, based on the texture value in the organoleptic test, it gets the best treatment in C treatment because it has a hardness level of 49.03% which produces jerky which is not too hard and not too crispy.

3.4 Chemical Analysis of the Product

3.4.1 Proximate Analysis

3.4.1.1 Moisture Content

Water is an important component in food, because it can affect the appearance of the texture and taste of food, because water in food also determines the acceptability, freshness, and durability of the product [18]. The average value of water content in the Moringa leaves jerky analogue with the addition of tapioca can be seen in Table 4.

Table 4. Proximate Analysis of the Product

Addition of Tapioca Powder	Moisture Content (%) ± SD	Ash Content (%) ± SD	Fat Content (%) ± SD	Protein Content (%) ± SD	Crude Fiber ((%) ± SD
B (50 g)	3.11 ± 0.19 a	0.94 ± 0.00	0.18 ± 0.02 a	8.24 ± 0.01 c	0,42 ± 0,01 b
C (55 g)	3.67 ± 0.67 a b	0.94 ± 0.00	0.19 ± 0.00 a	7.82 ± 0.01 b	0,34 ± 0,01 a
D (60 g)	4.00 ± 0.33 b	0.83 ± 0.20	0.21 ± 0.00 b	7.77 ± 0.02 a	0,32 ± 0,01 a

Note: The number in the same column followed by unequal lowercase letter are significantly different at α = 5% by Duncan's Multiple Range Test (DMNRT)

Table 4. shows the moisture content of the product ranged between 3.11-4.00%. This is consistent with the another research [12], that the more tapioca is added to the cassava leaf jerky, the higher the moisture content of the product. Therefore, the more tapioca added, the more moisture content. The difference in the amount of starch in a material causes a difference in the value of water absorption capacity. The amount of starch contained in tapioca flour will affect the number of water molecules trapped in the gelatinization process.

Frying is done until the bubbles in the oil are used up, which indicates the water in the jerky has been reduced. The more tapioca, the higher moisture content in the product. This is also influenced by the value of the gelatinization process that occurred in the previous treatment process. The moisture content in the product has met the Indonesia standard which is a maximum of 12%

3.4.1.2 Ash Content

Ash is an inorganic residue that is obtained by combustion or heating at high temperatures (> 450^0C) and / or obstruction of organic components with strong acids. This inorganic residue consists of various minerals whose composition and amount depend on the type of food and the analysis method

used. The average value of ash content in the analogue jerky batter mixture with the addition of tapioca can be seen in the Table 4.

Table 4. shows that the ash content produced in analogue jerky ranged from 0.82 to 0.94%. The more tapioca that is added, the ash of product was decreases, but from statistical analysis at α level of 5%, there is no significant difference. Ash content is influenced by the presence of mineral content in raw materials. Based on the analysis of raw materials, Moringa leaves have ash content of 2.67%, while tapioca flour as stated in the SNI 3451-2011 quality standard is only max. 0.5%. Compared to SNI 2908: 2013 [21] regarding the quality requirements of beef jerky, the ash content of the analogue of the Moringa leaf jerky has a higher ash content than the Indonesia standard, which is a maximum of 0.5%.

3.4.1.3 Fat Content

Fat is a non-polar ester compound that is insoluble in water produced by plants and animals. Fat has an important function in the formation of food processing, namely as an energy source, contributing to the formation of texture and sensory quality of food products, heat transfer media in the frying process and solvents for fat-soluble essential vitamins (A, D, E, and K). By using statistical analysis, the fat content of the jerky before frying between the addition of different tapioca, had no significant effect on the α level of 5%.

Table 4. shows that the level of analogue jerky fat ranged from 0.18 to 0.24%. Fat content in analogue jerky was significantly different at the 5% level. This is thought to be influenced by the water content contained in jerky so that it affects the amount of fat that will fill the empty cavity due to water evaporation.

The higher tapioca that is added, the higher the fat content in the product produced. The same explanation as the explanation of yield. The fat content contained in analogue jerky is obtained from the frying process, as a result of the water content that was originally bound to the dough then evaporated through the frying process and gives rise to empty voids inside, then the empty cavities are replaced by cooking oil trapped inside, so the more water content in food products, the more oil is absorbed because the spaces where water is bound are replaced by frying oil. If the levels of Moringa leaves jerky analogue jerky compared with SNI 2908-2013 [21], beef jerky fat content, then the content of analogue jerky has met the maximum quality requirements, the maximum fat content is 3%

3.4.1.4 Protein Content

Protein is a substance that plays a role in the regeneration of body cells, muscle building and energy sources and is a source of amino acids that contain elements of Carbon (C), Hydrogen (H), Oxygen (O) and Nitrogen (N) [18]. The results of the analysis of protein levels that have been carried out in the study can be seen in Table 4.

Table 4. shows the levels of protein in analogue jerky ranged from 7.77-8.24%. The highest protein content was in treatment B that was 8.24%, and the lowest in treatment D was 7.77%. The higher tapioca that is added the less protein produced. This is thought to be influenced by the protein content in the raw material. Moringa leaves contain higher protein than tapioca flour. The higher the concentration of Moringa leaves in the material, the resulting protein also increases. Based on the variance at 5% level, the addition of tapioca flour has a significantly different effect on the protein content.

From the raw material test, the protein content in fresh Moringa leaves is 9.23%, while the protein in tapioca flour is only 0.5% [21]. Moringa leaf consists of complete amino acids consisting of 8 essential amino acids in the form of isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, and 10 non-essential amino acids in the form of alanine, arginine, aspartic acid, cystine, glutamic acid, glycine, histidine, serine, proline, tyrosine [1]. The protein content obtained in the product is quite low. In the study of [12], the protein content of analogue jerky made from cassava leaves with the addition of oyster mushroom powder has a protein content ranging from 12.33-16.45%. This high protein content comes from oyster mushroom powder which is added to the

formulation. The protein content of analogue jerky produced from Moringa leaves is still far below the quality standard of beef jerky according to SNI 2908-2013 [22] which is a minimum of 18%.

3.4.1.5 Crude Fibre

Crude fibre is the residue of food consisting of cellulose and lignin after being treated with boiling acid and alkali. Crude fibre cannot be digested and cannot be absorbed in the human digestive tract, but crude fibre has a function for health maintenance, disease prevention, and an important component in nutritional therapy. The results of analogous jerky fibre analysis produced can be seen in Table 4.

Based on Table 4. it is known that the levels of crude fibre in analogue jerky ranged from 0.32 to 0.42%. The highest crude fibre content was in treatment B at 0.42%, and the smallest was in treatment D at 0.32%. Variance analysis showed that the addition of different tapioca gave a real influence on the α level of 5% on the content of crude fibre of analogue jerky.

The level of crude fibre in analogue jerky is greatly influenced by the fibre content found in moringa leaves. Tapioca does not contain crude fibre because it only consists of starches from cassava. Crude fibre has several benefits for the body including can reduce bad cholesterol and make you feel full longer. This process will slow down the absorption of food and maintain blood sugar balance in the body because most of the fat is burned [23].

3.4.2 Calcium Level

According to Shita and Sulistiyani [24], calcium is an important mineral for humans, 99% of calcium in the human body is in bones. The results of analytical beef jerky calcium analysis can be seen in Table 5.

Table 5. Calcium Content of the Product

Addition of Tapioca Powder	Value (mg/100g)±SD
B (50 g)	203,43 ± 0,03 a
C (55 g)	198,10 ± 0,01 a b
D (60 g)	161,80 ± 0,02 b

Note: The number in the same column followed by unequal lowercase letter are significantly different at α = 5%, by Duncan's Multiple Range Test (DMNRT)

Table 5 shows that calcium levels in analogue jerky ranged from 161.80-203.43 mg / 100 gram. The highest value was in treatment B that was 203.43 mg / 100 gram, and the lowest value was in treatment D that was 161.80 mg / 100 gram.

The level of calcium obtained decreases with increasing amount of tapioca added. This is thought to be related to the content of Moringa leaves. From the results of the raw material test, fresh Moringa leaves contain calcium of 643.17 mg / 100 g. Although calcium levels are not listed in SNI 2908-2013, calcium levels in analogue jerky made from Moringa leaves need to be known, because Moringa leaves contain calcium that is high enough, so that jerky made from Moringa leaves has added value, namely high calcium.

3.4.3 Free Fatty Acid (FFA)

Free fatty acids are acids that are released in the process of fat hydrolysis. The presence of water in food can cause the hydrolysis of fats in the food that produce free fatty acids.

Table 6. Free Fatty Acid (FFA) Content of the Product

Addition of Tapioca Powder	Value (%±SD)
B (50 g)	-
C (55 g)	-
D (60 g)	-

Note: (-) the value is not detected

Table 6 shows that the free fatty acids in the analogue jerky produced were not detected. This is thought to be associated with a low water content in the product which is 3.11 - 4.00. Low water

content in materials associated with low hydrolysis activity that occurs, so it is associated with low free fatty acids that are formed.

3.4.4 Peroxide Number

Peroxide number is an important parameter to know the level of damage that occurs in fat caused by oxidation process if fat or oil reacts with oxygen. Peroxide numbers in analog jerky can be seen in table 7.

Table 7. Peroxide Number of the Product

Addition of Tapioca Powder	Value (meg/1000g)±SD
B (50 g)	-
C (55 g)	-
D (60 g)	-

Note: (-) the value is not detected

Based on Table 7. it is known that the peroxide number in the analogue of the fried Moringa leaf jerky is produced. This is evidenced by the color change that does not occur when titrated, which indicates that peroxide has not formed on the analogue jerky. These tests prove that analogue jerky made from Moringa leaves is safe for consumption. The amount of peroxide in food items greater than 100 me q/ 1000 g is said to be dangerous and is not permitted in oily foods. In addition, the presence of high peroxide in food will be indicated from the smell [25].

4. Conclusion

Based on the results of the research that has been carried out, the following conclusions can be drawn:

1. The addition of tapioca flour produces analogue jerky which is organoleptically accepted with a value ≥ 3.6 is the addition of tapioca flour by 50 g, 55 g and 60 g
2. The addition of tapioca flour affects the yield, hardness, moisture content, fat content, protein content, crude fibre content and calcium jerky analogue calcium content and there is no effect of adding tapioca flour to ash content of analogue jerky.
3. Free fatty acids and peroxide numbers in analogue jerky made from moringa leaves, not detected.
4. The best product was analogue jerky which is made from Moringa leaves with the addition of tapioca flour by 50 g. The composition was a moisture content of 3.11 ± 0.19%, ash content of 0.94 ± 0.00%, fat content of 0.18 ± 0.02%, protein content of 8, 24 ± 0.01%, calcium levels 203.43 ± 0.03%, crude fibre content 0.42 ± 0.01%. No free fatty acids and number of peroxides were detected in the analogue jerky.

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