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The effect of lesser yam tuber flour (*Dioscorea esculenta*) and cooking methods on meat analogue chemical and textural properties

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KEYWORDS

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ABSTRACT

The addition of carbohydrates on gluten meat analogue has the potency to improve texture, such as lesser yam flour. It can be processed by steaming and baking. This study aimed to determine, analyze, evaluate the effect of cooking methods (steaming and baking) and substitution of lesser yam tuber flour (0%, 5%, 10%, 15%) on the texture of meat analogue and chemical properties only for the best meat analogue. This study used Randomized Block Design, Nested Design of 3 replications with 2 factors, levels of lesser yam tuber flour nested in cooking methods. The texture of meat analogue was compared to beef texture. The results showed that the cooking method affected hardness and cohesiveness significantly. The substitution of lesser yam tuber flour significantly affected hardness, springiness, cohesiveness and chewability. The best steamed meat analogue was at 5% substitution level of lesser yam tuber flour, contain of 49.79% moisture content, 28.39% protein, 17.04% carbohydrates, 2.57% ash, 2.21% fat and red grayish color. The best baked meat analogue was at 0% substitution level of lesser yam tuber flour, contain of 48.64% moisture content, 29.87% protein, 16.89% carbohydrates, 2.60% ash, 2.00% fat and red grayish color. The steamed meat analogue was more similar to beef, than the baked meat analogue. This production of a meat analogue would be suitable as a simple household-scale meat substituent.

Introduction

Gluten meat analogues were known 1500 years ago as a high-protein, low-calorie meat substituent. Meat analogue has good prospects in the future. Its growth will reach 10% of world meat consumption in 5 years (Gerhardt et al., 2019). It has the potency to be widely developed with improved quality that is increasingly similar to actual meat or beef, or even better in terms of nutrition to functional properties.

Gluten meat analogue as plant-based meat has high viscoelasticity characteristics. Gluten plays a role in making fibrous and chewy textures and providing a protein value of meat analogue (Ortolan and Steel, 2017). Its quality improvement can be supported by adding other ingredients to produce better meat analogue in terms of texture, taste and nutrition (Rubio et al., 2020). One of those is carbohydrates to improve texture, bind water, immobilize fat and reduce syneresis in meat analogue (Sha and Xiong, 2020). Lesser yam tuber flour (*Dioscorea esculenta*), as a rarely used local ingredient, has the potency to be created into meat analogues due to its high carbohydrates content. Harlia's research (2018) was about artificial meat from lesser yam tuber flour, soy protein isolates using the extrusion technique (puff dry). The best formulation was the 10-30% lesser yam tuber flour, which stands on the value of WHC (*Water Holding Capacity*), OHC (*Oil Holding Capacity*), rehydration, swellability, texture and protein content. In that case, the WHC, OHC, rehydration and swellability were studied because of their type of puff dry meat analogue.

Meat analogue production varies from heating processes such as extrusion, simple cooking method (plant-based meat) to using cell-cultured technology (cell-based meat) (Santo et al., 2020). Simple cooking methods as boiling, frying, steaming, roasting are home-practicable (Wieser et al., 2020).

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Table 1. Meat analogue formulation (in units of weight)

The Cooking Methods	The Substitution of Lesser Yam Tuber Flour (%)	Vital Wheat Gluten (g)	Lesser Yam Tuber Flour (g)	Water (ml)	Angkak (g)	Crystal Coconut Oil (g)
Steaming (90°C±3°C)	0	44.0	0.0	34	2	5
	5	39.6	4.4	34	2	5
	10	35.2	8.8	34	2	5
	15	30.8	13.2	34	2	5
Baking (180°C)	0	44.0	0.0	34	2	5
	5	39.6	4.4	34	2	5
	10	35.2	8.8	34	2	5
	15	30.8	13.2	34	2	5

The cooking method has different principles that will give varying results, mainly in terms of texture. Parsons (2020) stated that boiling seitan produces soft and not chewy seitan, but it is the most complicated cooking method to control. Steaming provides firm-chewy seitan. Likewise, roasting is a more convenient method for firm seitan results (Parsons, 2020). Generally, the main texture parameters in meat analogue research are hardness, elasticity, cohesiveness and chewiness. The study by Angelis et al. (2020) tested meat analogue from fractionated oat protein and dry peas with texture parameters so as hardness, elasticity, cohesiveness and chewiness. Food texture plays an important role in determining the consumer's preference for product quality (Day and Golding, 2016)**.**

The previous research applied the lesser yam tuber flour in making meat analogue based on protein isolate using the extrusion technique (puff dry). This study used the lesser yam tuber flour in making gluten-based meat analogue with two cooking methods (steaming and baking) as the most common, efficient and simple (home-practicable) method to produce cooked meat analogue. The aims of this study were to determine, analyze and evaluate the effect of the cooking methods and the lesser yam tuber flour on meat analogue's textural properties.

Research Methods

Materials

The ingredients used in the production of meat analogue were vital wheat gluten (Golden Ante, Anhui Ante Food, China), lesser yam tuber flour (Hasil Bumiku, Yogyakarta), crystal coconut oil (Mamaco, PT. Sari Mas Permai, Surabaya), angkak as colouring ingredient (Cap Sahabat, Bandung), soy sauce (Pearl River Bridge, Guangdong PRB Bio-tech Co., China) and granulated mushroom bouillon (Totole, Shanghai Totole Food Co. Ltd, China), red onion, garlic, pepper powder (Ladaku, PT. Motasa Indonesia, Mojokerto) and sugar (Gulaku, Sugar Group Companies, Lampung). The materials in the test included Kjeldahl tablets (Merck), H2SO4, NaOH (Merck), boric acid pro-analysis, HCL pro-analysis, Kjeldahl indicator, phenolphthalein indicator, petroleum ether, oxalic acid obtained from the Food Chemistry and Biochemistry Laboratory, THP UB.

Experimental Design

The study was designed using Randomized Block Design with a Nested pattern of 2 factors in the form of 2 types of cooking methods (steaming 90°C±3°C; 60 minutes (Patton, 2012 with modification) and baking 180°C; 60 minutes (Sullivan, 2017 with modification) and the 4 levels of substitution of lesser yam tuber flour (0%, 5%, 10%, 15%) which was nested in each type of cooking methods. All treatments were done in 3 replications. Thus, there were 24 experimental units were obtained. The control variable was beef thigh which was boiled at 95°C for 60 minutes until cooked.

Meat Analogue Production

The dry ingredients (vital wheat gluten, lesser yam tuber flour (0%, 5%, 10%, 15% of the total vital wheat gluten and lesser yam tuber flour)) were scaled and mixed manually with coconut oil that had been compacted in the freezer and grated. Then, it is mixed with the wet spices (i.e. water, soy sauce, finely red onion and garlic, granulated mushroom bouillon, pepper powder) until they became a dough (Table 1). The dough was wrapped in aluminium foil with a thickness of 2 cm. Meat analogue was cooked by steaming method at 90°±3°C using stew pot and stove, while baking method at 180°C in an electric oven (Kirin) that was preheated for 15 minutes (250°C) and 5 minutes (180°C). Cooking was done for 60 minutes. Every 30 minutes, the meat analogue was turned on the other side. After cooking, the cooked meat analogue was drained and ready for analysis.

Texture Profile Analysis
The texture properties were tested by texture profile analysis method using a Brookfield CT3 Texture Analyzer (operation condition is shown on Table 2) with parameters of hardness, elasticity, cohesiveness and chewiness of meat analogue. Texture profile analysis focuses on imitating actual mouth bites food.

Table 2. Operation condition of Brookfield CT3 texture analyzer

Criteria	Condition	Criteria	Condition	Criteria	Condition
Test type	Compression	Return speed	10 mm/s	Date rate	4 points/sec
Target	10 mm	# of cycles	2	Probe	TA44
Hold time	0 s	Recovery time	0 s	Fixture	TA-BT-KI
Trigger load	6,8 g	Same trigger	False	Load cell	1000 g
Test Speed	10 mm/s	Pretest speed	2 mm/s		

The parameters are hardness, brittleness, springiness, cohesiveness, adhesiveness, gumminess and chewiness. Angelis et al. (2020) tested meat analogues of fractionated oat protein and dry peas with texture parameters such as hardness, elasticity, cohesiveness and chewiness. In addition, the parameters of hardness, cohesiveness and elasticity of meat analogue from gluten, red beans, soybean pulp and textured vegetable protein were tested using method described in Tristantini and Susanti (2016), without any difference priority level in the best treatment decision.

Moisture Content Analysis *(AOAC, 2005)*
The 3 g of sample was placed in a dried Petri dish (that had been dried and weighed before) and was dried in an oven (WTB Binder) at 105°C for 3 hours. Then, the sample in Petri dishes was cooled in a desiccator (Nalgene) for 15 minutes and was weighed. The sample was dried again in the oven (WTB Binder) for 1 hour, cooled in a desiccator (Nalgene) and weighed the results. That procedure was repeated until getting a constant weight with a maximum sample weighing difference of 0.0002 g. Moisture content was obtained by the formulation of moisture content.

Protein Content Analysis *(AOAC, 2005)*
The crushing of the sample was followed by weighing the sample of 1 g. The sample was mixed with a grey Kjeldahl tablet in a Kjeldahl flask (Buchi). The Kjeldahl flask was heated (420 °C) in an electric stove fume hood until it was boiled and the liquid became clear. In a separate Erlenmeyer, 50 mL of 4% H_3BO_3 was mixed with 4 drops of Kjeldahl indicator until homogeneous. Next to the distillation steps, the Kjeldahl flask was installed and filled with 80 ml of 30% NaOH. Erlenmeyer was installed under the cooler so that the end of the pipe hit the boric acid in distillation machine (UDK 129). The distillation process occurred with a heating time of about 3 minutes. As it finished, the distillate was titrated using standardized 0.1 N HCl. Protein content was obtained by the formulation of protein content.

Fat Content Analysis *(AOAC, 2005)*
The empty fat flasks and paper sleeves were dried in an oven (WTB Binder) at 105°C for 2 hours, then they were cooled in a desiccator (Nalgene) for 15 minutes and weighed. The 5 g of sample was placed on a paper sleeve and was dried in the oven (WTB Binder) for 1 hour. Then, it was cooled in a desiccator (Nalgene) for 15 minutes. Equipment of fat extraction (Gerhardt) was installed and the sample was extracted for 5 hours. After the extraction process, the fat flask was dried using an oven (WTB Binder) at 105°C for 1 hour and was cooled in a desiccator (Nalgene) for 15 minutes. Fat content was obtained by the formulation of fat content.

Ash Content Analysis *(AOAC, 2005)*
The porcelain was dried first in an oven (WTB Binder) at 105°C for 24 hours and was placed in a desiccator (Nalgene) for 15 minutes. The sample was crushed finely with a weight of 3 g and was put in the porcelain. The sample then was composed on a 600 Watt electric stove (Maspion) for 1 hour until it was black and was not emit smoke. Then, was ashed in the furnace (Thermolyne 47900) at a temperature of 640°C to a whitish colour (±4 hours). The ash was dried in an oven (WTB Binder) at 105°C for 1 hour, was

cooled in a desiccator (Nalgene) for 15 minutes. The sample was weighed and calculated by the formulation of ash content.

***Carbohydrate Content Analysis** (AOAC, 2005)*

Carbohydrate content was calculated using *by difference* method.

Colour Analysis

Colour was analyzed using Minolta CR10 Colour Reader (CIELAB method) and followed by measuring the chroma value to determine the type of colour and hue to indicate the intensity of the colour.

Data Analysis

The data of texture profile analysis is reported in the form of mean ± standard error. The primary data were analyzed using ANOVA 95% and post hoc test using BNJ / Tukey 5%. This study compared the textural properties of meat analogue and beef in terms of hardness, elasticity, cohesiveness and chewiness value to obtain the best meat analogue. The best meat analogue was determined using the Multiple Attribute Decision Making (MADM) type of Simple Additive Weighting (SAW) method. The highest preference value was the best meat analogue because it is getting better or more similar to the results we expect.

Results and Discussion

Hardness

The parameter of hardness is one of the primary parameters in meat analogue texture which shows the maximum force to press a food material between the molars (Chandra and Shamasundar, 2015). Hardness values were obtained using the Texture Analyzer of the maximum force at the first cycles. It can find out how hard or easy to press the food by the molars. Hardness becomes an important parameter because consumers certainly want tender, easy-to-bite and not tough meat, same as beef.

Table 3. Texture quality of meat analogue effect of cooking methods

The Cooking Methods	Hardness (g)	Springiness (mm)	Cohesiveness	Chewiness (g.mm)
Steaming (90°C±3°C)	701.03 ± 112.13^{b}	8.20 ± 0.76^{a}	0.90 ± 0.12^{b}	5692.41 ± 918.94^{a}
Baking (180°C)	832.72 ± 39.50^{a}	8.29 ± 0.71^{a}	1.11 ± 0.22^{a}	5728.45 ± 1241.54^{a}

Note: Data presented was the mean values of 4 levels of substitution of lesser yam tuber flour ± standard deviation. Mean values within a column followed by the same letters are not significantly different ($p < 0.05$) according to Tukey Test.

Tabel 4. Texture quality of meat analogue effect of the substitution levels of lesser yam tuber flour nested in the cooking methods

The Cooking Methods	The substitution levels of lesser yam tuber flour (%)	Hardness (g)	Springiness (mm)	Cohesiveness	Chewiness (g.mm)
Steaming (90°C±3°C)	0	783.00 ± 20.51^{ab}	7.30 ± 0.25^{e}	0.96 ± 0.04^{bc}	6361.75± 592.67^{ab}
	5	770.83 ± 69.89^{ab}	7.68 ± 0.36^{de}	0.76 ± 0.04^{d}	5675.31 ± 67.75^{bc}
	10	710.60 ± 89.42^{b}	8.61 ± 0.10^{bc}	1.03 ± 0.03^{b}	4200.78 ± 476.93^{cd}
	15	539.67 ± 18.59^{c}	9.22 ± 0.21^{ab}	0.84 ± 0.02^{cd}	6531.79 ± 138.87^{ab}
Baking (180°C)	0	865.27 ± 7.88^{a}	8.14 ± 0.28^{cd}	0.96 ± 0.04^{bc}	7489.34 ± 879.78^{a}
	5	840.53 ± 57.95^{ab}	9.28 ± 0.19^{a}	1.10 ± 0.13^{b}	5693.95 ± 1018.66^{bc}
	10	775.50 ± 43.32^{ab}	7.29 ± 0.22^{e}	0.98 ± 0.07^{bc}	5752.25 ± 310.95^{bc}
	15	849.57 ± 16.28^{ab}	8.48 ± 0.06^{c}	1.43 ± 0.04^{a}	3978.24 ± 340.89^{d}

Note: Data presented was the mean values of 4 levels of substitution of lesser yam tuber flour ± standard deviation. Mean values within a column followed by the same letters are not significantly different ($p < 0.05$) according to Tukey Test.

The results of statistical tests are shown in Table 3 that the hardness value between cooking methods was significantly different with the mean hardness value on baking (180°C) which was 832.72 g which was higher than the mean hardness value of steaming (90°C±3°C) which was 701.03 g. The reason for this is the water content in the meat analogue. In this study, steaming was carried out at 90°C ± 3°C for 60 minutes and baking at 180°C for 60 minutes. The steaming method is convection heating using hot steam, while baking uses hot air (Potter, 2015). The higher the cooking temperature, the more water molecules evaporate, especially from the surface of the food, into a gas. Guiné (2018) mentioned that the high temperature affects physical and chemical changes lead to the hardening dried surface which is impenetrable and keeps the inside moist. The structural changes during heating affect its final texture, based on water elimination rate (Guiné, 2018). This will produce different meat analogues, baking (dry heat processing) makes meat analogue drier than steaming (wet heat processing). The surface of the baked meat analogue tends to be drier, which will affect the biting process or the pressure during the chewing process. Thus, affecting the hardness value of meat analogue tends to be higher than in the type of steaming (90°C±3°C). As in Puspitasari's research (2008), it is suspected that the hardness of meatball products from seaweed substitution increases along with the decrease in the water content of the product.

Lesser yam tuber flour substitution has a significant effect on the hardness of meat analogue with a decreasing trend as the substitution level of lesser yam tuber flour increases as shown in Table 4. From Table 4, it can be seen that the maximum hardness value has been obtained for the lowest addition of lesser yam tuber flour (0%), whereas the minimum hardness value has been obtained for 10% (baking) and 15% (steaming) addition of lesser yam tuber flour. The decrease could be due to the reduced composition of gluten which has a role in giving solid compact properties to meat analogue, which was partially replaced by carbohydrates from lesser yam tuber flour. During the cooking process, starch absorbs water so that the starch granules will expand. This causes the texture of the product to become softer. Puspitasari (2008) also mentioned that the higher the water content of the meatball product that is retained, the softer it becomes. The softer texture will require less force to achieve product deformation, so the hardness value will decrease. In the case of meat analogue, the water level that can be retained by a product is influenced by the hydrocolloid nature of lesser yam tuber starch, especially its glucomannan with the hydrocolloid properties which can be used as a thickener (Herlina et al., 2020). Another study discussed that higher glucomannan level (1.5%) would absorb more water that can decrease hardness level, in that study was a bread (Kumala et al., 2020).

Springiness

The elasticity parameter shows how much the product can return to its original condition after being given the first cycle (Chandra and Shamasundar, 2015). The elasticity or springiness value is obtained from texture testing using a Texture Analyzer which is shown from the distance travelled during the second cycle to the maximum force after getting the first cycle. The higher the springiness value, the more masticatory energy is required (Chandra and Shamasundar, 2015). It becomes a crucial parameter in gluten-based meat analogue as gluten has elastic and cohesive properties. By measuring springiness, the desired level can be controlled. So, the need for materials that provide springiness also can be adjusted.

In this study, the cooking methods did not affect significantly on the springiness of the meat analogue (Table 3). Based on statistical results in Table 4, lesser yam tuber flour substitution has a significant effect on the elasticity of meat analogue with a tendency to increase as the substitution level of lesser yam tuber flour increases. Gluten components can affect the elasticity of a product, the higher the gluten composition the more elastic the resulting product such as noodles and bread. The viscoelastic of gluten will produce a rubbery chewy character in the final product (Kumar, 2014). In this study, there was an increase in the elasticity value along with the increasing level of substitution of lesser yam tuber flour in the meat analogue. This can be possible because the effect of lesser yam tuber flour starch is greater than the effect of decreasing the level of gluten. Starch consists of amylose and amylopectin with different properties. According to Bakar et al. (2009), the interaction of the protein with starch in food systems can increase gel strength which is related to the increase in protein matrix density and the formation of elastic starch globules. Then, it was also mentioned that the addition of starch in the food system can improve physicochemical properties in the form of gel formation and final product properties (Bakar et al., 2009). The presence of high levels of soluble amylose and the swelling power of starch can increase the elasticity of the formed starch gel (Eliasson, 1996).

Cohesiveness

Cohesiveness is the strength of the internal bonds that compose up food ingredients. This indicates the extent to which food can be deformed before it disintegrates. The texture analyzer shows the cohesiveness value from the calculation of the area under the second cycle curve divided by the area under the first cycle curve (Chandra and Shamasundar, 2015). In the Brookefield CT-3 Texture Profile Analyzer tool, cohesiveness value is obtained from the division of Hardness Work Cycle 2 with Hardness Work Cycle 1. The high cohesiveness implies the strong internal structure of the food in maintaining its shape when compressed or the more compact the food is. It indicates the product's ability to stick together. It is related to the whole structure and composition of food, including gluten as the main ingredient in this meat analogue. As the preference consumer that desires easy-to-chew meat include meat analogue as a meat substitute (Ganjyal, 2020), it is important to measure cohesiveness which indicates the product's ability to stick together as take effect on chewiness.

In Table 3, the cooking methods have a significant effect on the cohesiveness of the meat analogue. This could be due to the high-temperature baking method (180°C, 60 minutes) causing the meat analogue surface to become drier and harder (Huriawati et al., 2016), compared to the steaming meat analogue surface (90°C±3°C). Therefore, that dry surface is more compact and seems tough, which will affect the analysis of the overall cohesiveness of the meat analogue, where the texture analyzer probe will touch the surface of the meat analogue first.

The use of vital wheat gluten plays an important role as the main component of meat analogue-forming. Gluten is formed by protein gliadin for extensibility and cohesiveness, and glutenin for elasticity. The lower the gluten index means the higher the gliadin level will provide a higher cohesiveness level on its product (Barak et al., 2014). Thus, the use of vital wheat gluten has a role in the formation of texture in the form of cohesiveness of the meat analogue. In this study, the results (Table 4) show that between levels of substitution of lesser yam tuber flour nested in the cooking methods. There is a notational similarity trend which means that the value of the cohesiveness is not significantly different between treatments except for some deviations. Similarly, research by Tristantini and Susanti (2016) made extrusion-based meat analogue from gluten, red bean flour, soybean pulp and texturized vegetable protein (TVP). The results of this study showed that there was no significant effect of raw material variation on the cohesiveness of type I meat analogue (gluten, red bean flour and soybean pulp) and type II meat analogue (gluten, red bean flour, soybean pulp and texturized vegetable protein (TVP)) (Tristantini and Susanti, 2016). The existence of these deviations can be made possible due to the non-uniformity of the dough in the production of meat analogue.

Chewiness

The chewiness is the amount of energy to chew food products, especially solids. In the texture profile analyzer, the value of chewiness is obtained by multiplying the hardness, cohesiveness and elasticity value (Duma-Kocan et al., 2020). Since food texture plays a role in determining product quality, it is important to measure chewiness in meat analogue. The high chewiness indicates more energy is required to chew it**.** Based on ISO 5492:2008 on Sensory Analysis-Vocabulary, the definition of tender is for low chewiness food. The moderate chewiness is called chewy, while high chewiness is called tough (ISO, 2008). The cohesiveness is crucial to be measured as it determines the tenderness of the meat analogue to provide consumers' desire for the tender and meat-like chewy meat analogue.

The results of meat analogue research on chewiness parameters are shown in Table 4. Lesser yam tuber flour substitution had a significant effect on the chewiness of meat analogue. The decreasing value of chewiness along with the increasing level of substitution of lesser yam tuber flour in meat analogue was influenced by the amount of gluten flour used. Gluten has a role in the formation of products that are elastic and chewy. The higher the gluten level used, the greater the stability and chewiness of the product (Kumar, 2014). Due to the viscoelastic and cohesive nature of gluten, it has internal strength which makes the product more difficult to chew. The purer the gluten used, the higher the gluten concentration, so that it can produce a chewier product (Kumar, 2014). Gluten can trap air and form a cavity structure in it so that it will contribute to forming a fibrous and chewy texture similar to actual meat, as well as providing protein nutritional value (Ortolan and Steel, 2017).

The Best Meat Analogue

The importance of determining the best meat analogue is to obtain the most similar meat analogue to the beef texture. More similar to the beef, the greater the chance of meat analogue to be accepted by consumers. It can also be a reference for further study when making mat analogue with similar ingredients. The best meat analogue was determined by comparing the parameter value of each analogue meat with the beef texture value as the control variable. Based on MADM-SAW, the best meat analogue was at the level of substitution of lesser yam tuber flour 5% for steaming (90°C±3°C) (Figure 1) and the substitution level of lesser yam tuber flour 0 % for baking (180°C) (Figure 2) with characteristics as shown in Table 5. This means that the factor produced the most similar analogue meat texture quality in each cooking method with preference values of 0.84 and 0.81. The higher or closer to 1, the more similar meat analogue texture to the beef.

The proximate analysis between the best meat analogue of steaming and baking is shown in Table 5. The water content of meat analogue of baking (180°C) was lower than steaming (90°C±3°C) due to differences in heating methods. Baking (180°C) uses hot air as an intermediary (dry heat) to reduce the air in the product more than steaming using steam (wet heat) (Datta and Rakesh, 2013). The second-largest component is protein. The high protein content of meat analogue is obtained from the main ingredient vital wheat gluten, which is used higher in the best meat analogue of baking (180°C) instead of the best meat analogue of steaming (90°C±3°C).

Table 5. Characteristics physic and chemical of best meat analogue

Parameters	**The best steamed meat analogue (90°C±3°C)**	**The best baked meat analogue (180°C)**
Moisture Content (%)	49.79	48.64
Protein Content (%)	28.39	29.87
Carbohydrate Content (%)	17.04	16.89
Ash Content (%)	2.57	2.60
Fat Content (%)	2.21	2.00
Colour		
L	40.35	40.90
a	11.00	9.90
b	9.70	9.50
Hue angle (°)	41.34°	43.92°
Chroma	14.67	13.08
Textures		
Hardness (g)	770.83	865.27
Springiness (mm)	7.68	8.14
Cohesiveness	0.76	0.96
Chewiness (g.mm)	5675.31	7489.34

Figure 1. The best steamed meat analogue (90°C±3°C)

Figure 2. The best baked meat analogue (180°C)

The carbohydrate content in meat analogue was calculated from the lesser yam flour and vital wheat gluten which still contains few carbohydrates. The 5% addition of lesser yam tuber flour in the best meat analogue of the steaming method obtain the higher carbohydrate content than the best meat analogue of baking. The fat content was from coconut oil which was added by 4%. The processed meat analogue had a lower fat content. This decreasing fat content can be caused by heating. Coconut oil was melted and some of it came out of the meat analogue. The ash content in the meat analogue can indicate the mineral content of the food. The meat analogue has a colour value that tends to be red with a greyish hue.

Conclusion

The cooking methods only significantly affected the hardness and cohesiveness, while the substitution level of lesser yam tuber flour significantly affected the hardness, elasticity, cohesiveness and chewiness of meat analogue. The best meat analogues were at the substitution level of lesser yam tuber flour of 5% (steaming 90°C±3°C) and 0% (roasting 180°C). The steaming produced a better meat analogue texture than roasting. Overall, the higher the substitution level of lesser yam tuber flour will result in a lower similarity meat analogue texture with beef texture. Recommendation for further studies in this topic is that more methodological work is needed on how to objectify this meat analogue, including further sensory analysis and exploration of consumer preference in this type of meat analogue.

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