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THE EFFECT OF ELEPHANT FOOT YAM (*Amorphophallus campanulatus*) FLOUR AND SOYBEAN OIL ADDITION ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF BEEF SAUSAGE

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ABSTRACT

The texture of sausage was affected by its binding agent. Elephant foot yam *(Amorphophallus campanulatus)* flour was a potential natural binding agent and filler for sausage. The objective of this study was to evaluate the effect of elephant foot yam flour and soybean oil addition to the physicochemical properties and sensory attributes of beef sausage. A randomized block design with two factors and three replications were employed. Three addition levels (10%, 15% and 20% of meat weight) were used for both elephant foot yam flour and soybean oil. The results showed that the addition of elephant foot yam flour significantly ($P \leq 0.01$) affect the water-holding capacity (WHC) and sausage texture. The effect ($P \leq 0.05$) was also observed on the redness color (a* value). However, no effect was found on pH, L and b* values. On the other hand, the WHC and sausage texture were also significantly ($P \leq 0.05$) affected by soybean oil addition without altering pH and color. The highest addition level (20%) for both elephant foot yam flour and soybean oil showed a firm and compact beef sausage micro-structure with small pores. The highest fat and crude fiber content were also found in this group (20% addition level) and the sensory attributes (texture, aroma and taste) of the former group were comparable with the group with lowest addition level (10%). Therefore, elephant foot yam flour can be used as filler for producing both reduced-fat and typical beef sausage.

Keywords: Emulsified sausage; filler; gelling properties; technological properties

INTRODUCTION

Sausage is a meat-based food product made from ground beef mixed with filling and binding agents as well as other seasonings then placed into sausage casing. Basically, the sausage production is a simple process, involving the controlled structural and chemical changes of meat determined by the used ingredients (Essien, 2003). Non meat ingredients such as starch, protein isolate and dietary fiber, are commonly added in order to improve the quality as well as production cost (Abdolghafour and Saghir, 2014). It is considering that those compounds would have water binding properties, thus affect the sausage texture, emulsion stability, color, cooking loss, and flavor (Prastini and Widjanarko, 2015). Fat is also commonly added to the sausage mixture to make up for the fat loss during cooking, decrease the cell wall breakdown, and to improve the sausage flavor (Essien, 2003). The added fat could be both in a solid (beef or pork fat) or liquid (natural oil) form. One of the potential fat sourced ingredients to be added to the sausage is soybean oil, as it has better fatty acid content compared to most solid fat, has zero cholesterol, rich of unsaturated fat (linolenic and linoleic acid), and antioxidants (Isa, 2011).

Elephant foot yam flour is made from elephant foot yam bulb which had 68.21% starch (28.98 amylose), 13.71% dietary fiber (8.44% dissolved and 5.27% undissolved fiber), and *in vitro* digestibility at 61.75% (Faridah, 2005). The high starch and dietary fiber content in elephant foot yam flour showed its potential to be used as binding agent in meat processing, as both compounds had the ability to bind water and form gel. Elephant foot yam is in the family of porang (*Amorphophallus muwlleri* Blume) that contained high dissolved dietary fiber known as glucomannan, which reached 64.98% (Prastini and Widjanarko, 2015). Faridah (2005) added that elephant foot yam flour had low glycemic index (42) and showed a promising potential to be utilized as functional food for human health. In this study, we evaluate the effect of elephant foot yam flour and soybean oil addition on the physicochemical and sensory properties of beef sausage.

MATERIALS AND METHODS

Elephant foot yam flour and beef sausage production

The meat used in this research is the round part of beef meat from local market in Malang, Indonesia. The beef meat was trimmed from subcutaneous fat. The elephant foot yam flour was produced from elephant foot yam bulb by following Faridah (2005). The bulb was peeled, cut and washed and then soaked in 3% salt water. The bulb was then heated at 50°C on the oven for 12 h, grinded and sifted with 100 mesh screens.

The produced elephant foot yam flour had 9.49% moisture, 7.02% protein, 0.62% fat, 10.85% ash, 71.98% carbohydrate, 4.22% crude fiber, 68.21% starch, and 26.87% dietary fiber. The soybean oil used in this study contained 8% saturated fat, 13.33% unsaturated fat, and 32% double bond unsaturated fat for each 2000 kcal. The research was conducted in a randomized block design with two factorials to understand the optimum elephant yam flour and soybean oil addition. The first factor is the elephant foot yam flour additions (S1 = 10%; S2 = 15%; and S3 = 20%), and the s factor is the soybean oil additions (L1 = 10%; L2 = 15%; and L3 = 20%) based on

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the beef weight, respectively. Other used ingredients were 20 g salt, 15 g sucrose, 15 g seasoning, 60 g yolk and 300 g ice for 1 kg of beef meat. The beef meat was grinded in the meat grinder, and then mixed with other ingredients in the chopper, except for the elephant foot yam flour which was added little by little and then followed with soybean oil addition. The sausage mixture was then placed in the polyamide plastic sausage casing with the diameter at 16.86 mm by using hydraulic sausage filling machine, then boiled at 80°C for 20 min, placed in a 5°C ice cold water for 10 min, and drained before analyzed.

pH

As much as 5 g of beef sausage was placed on 50 mL Erlenmeyer flask, added with 20 mL distilled water, and then homogenized. The pH was then measured to the solution by using pH meter. The measurement was done for 2 times for each sample.

Color

The color measurement was done on the inner part of the sausage by using Color Reader (Minolta). The illuminant C was used to detect brigtness, and $BaCl_2$ was used as the standard. The color data were presented in stimulus coordinate system (CIE Lab color scale) to measure the L, a*, and b* color.

Water-holding capacity (WHC)

The water holding capacity of the beef sausage was measured by following Honikel and Hamm method (Suparno, 2005). As much as 0.3 g beef sausage was placed on Whatman filter paper no. 42 and then pressed between glass plates. The pressed sample on Whatman filter paper was then copied to the graph paper so that the produced wet area and pressed meat area could be measured. The WHC was then calculated as follow:

$$\text{mg } H_2O \text{ (X)} = \text{wet area (cm}^2\text{)} / 0.0948 - 8.0$$

$$\text{\%wet area} = \text{X / sample weight x 100\%}$$

$$\text{\%WHC} = \text{\%sample moisture - \%wet area}$$

Texture

The sausage texture was measured by using tensile strength texture analyzer (Stable Micro Systems). The hardness test was done by using initial speed (pre-speed) at 1.0 mm/s, reading speed (test) at 1.0 mm/s and final speed at (post-test) 10.0 mm/s, with pressing distance at 25% from the initial length by using P/35 probe cylinder for 60 (Schmiele *et al*., 2015).

Proximate and fiber analysis

The proximate analysis includes moisture, protein, fat and ash content analysis by following AOAC (2005), while the fiber content analysis was done by following Sudarmadji *et al*. (1984). The dietary fiber content was measured by using multienzyme method, where sample was initially dried and grinded into powder before analysis. The sample was the freeze dried and stored. The dietary fiber analysis includes insoluble dietary fiber and soluble dietary fiber (Asp *et al*., 1983).

Amino acids

The amino acids content was analyzed by using High Performance Liquid Chromatography as following Macrae (1990).

Microstructure

The sausage microstructure was observed by using scanning electron microscope (SEM, TM3000, Hitachi High-Technologies Corp., Tokyo, Japan). The sausage was cut at 1 to 2 mm thickness, and then fixed with 2.5% glutaraldehyde on 0.2 M phosphate buffer (pH 7) for 2 h, washed, soaked and then distilled for 1 h. The sample was then hydrated by using 50%, 60%, 70%, 80%, 90% and 100% ethanol for an h each. The sample was then placed on the holder,coated with gold, and then visualized by using the scanning electron microscope (Hashemi and Jafarpour, 2016).

Organoleptic test

The descriptive organoleptic test was done to understand the sensory properties of the beef sausage. The test was done by using method of single stimuli with sausage texture, aroma, and flavor as the measured variables. Each variable was scored from 1 to 5, with 1 indicates lowest sensory quality and 5 indicates the highest sensory quality (Lawless and Heymann, 1998).

Data analysis

All of the data were analysed by using two-way analysis of variance, and followed with Duncan's test to determine significance at P≤0.05.

RESULTS AND DISCUSSIONS

Physical properties

The analysis of variance to the physical properties of beef sausage with different elephant foot yam flour and soybean oil addition did not show any significant difference on pH between all treatments (Table 1). The pH of beef protein which highly determine the sausage pH in this research was around 6, which as according to Huff-Lonergan and Lonergan (2005) would have high water binding capacity, thus would initiate preferable protein-water-carbohydrate interaction. The addition of elephant foot yam flour and soybean oil in this study showed no effect on the pH of beef sausage, thus indicate its potential to be used for beef sausage production as both ingredients did not alter the sausage pH and did not affect the protein-water-carbohydrate interaction.

The water holding capacity of beef sausage in this study showed highly significant difference (P≤0.01) between different addition levels of elephant foot yam flour and soybean oil. The higher concentration of elephant foot yam flour showed higher WHC of beef sausage as well. The result is caused by the starch and dietary fiber content in the flour which had the emulsifying and gelation properties (Lorenzo *et al*., 2016).

Table 1. Physical properties of beef sausage with different elephant foot yam flour (EFYF) and soybean oil (SBO) addition

Treatments	pH	WHC (%)	Texture (N)	Color L	Color a*	Color b*
EFYF (%)						
10	6.38±0.32	54.42±4.86^{a}	27.99±1.41^{a}	46.08±2.18	15.60±0.40^{c}	16.41±1.83
15	5.71±0.39	59.09±1.16^{b}	30.43±0.97^{b}	45.39±1.88	14.41±0.46^{a}	16.22±1.37
20	6.39±0.36	64.81±1.39^{c}	39.43±4.58^{c}	45.41±2.06	14.50±0.17^{a}	16.36±1.64
SBO (%)						
10	6.41±2.50	60.43±2.27^{c}	31.42±1.56^{a}	45.93±1.70	15.04±1.73	16.39±1.38
15	6.45±2.52	59.50±4.43^{b}	32.39±1.46^{ab}	45.74±2.92	14.88±2.03	16.06±1.38
20	5.62±2.49	58.39±3.44^{a}	34.03±1.99^{c}	45.20±2.86	14.59±2.06	16.54±1.42

Description: Different superscripts on the same column indicate highly significant differences (P≤0.01) on WHC and texture, and significant differences (P≤0.05) on color a* with the addition of elephant foot yam flour.
Different superscripts on the same column indicate significant differences (P≤0.05) on WHC and texture with the addition of soybean oil.

The increased WHC of the beef sausage is also followed by its hardness texture, which would determine the sausage firmness or chewiness. The addition of fat compounds in meat would stabilize protein emulsion and produce smoother surface, even though the addition would also decrease the water holding capacity. However, the addition of soybean oil in this research did not show significant decrease in the WHC. Jamilah *et al*. (2009) explained that up to 30% starch addition would increase tensile strength, deformation and gel strength of fish meat, and in addition, would increase the water absorption as well. The addition of elephant foot yam flour and soybean oil on beef sausage showed a highly significant interactions (P≤0.01) to the sausage hardness texture and WHC (Table 2).

This showed that the elephant foot yam flour could be used as filling and binding agent which incorporate with soybean oil to form a good protein emulsion. The higher of elephant foot yam flour addition and soybean oil showed significant rheological change due to the starch gelation. The electrostatic interaction of protein and starch would form stable dispersion within the sausage (Jamila *et al*., 2009). Zhang *et al*. (2016) also described that konjac glucomannan had water absorbing, gelation, and emulsifying properties.

Table 2. Interaction of different elephant foot yam flour (EFYF) and soybean oil (SBO) addition to the physical properties of beef sausage

Treatments	Texture (N)	Color L	WHC
EFYF 10% SBO 10%	28.49 a	45.57 ab	56.18 c
EFYF 10% SBO 15%	27.94 a	46.10 ab	54.10 b
EFYF 10% SBO 20%	27.56 a	46.20 b	52.98 a
EFYF 15% SBO 105	27.30 a	45.50 a	59.91 e
EFYF 15% SBO 15%	30.06 a	45.37 a	59.14 e
EFYF 15% SBO 20%	33.93 b	45.17 a	58.22 d
EFYF 20% SBO 10%	38.48 c	45.07 a	65.19 g
EFYF 20% SBO 15%	39.19 c	44.97 a	65.27 g
EFYF 20% SBO 20%	40.61 c	44.70 a	63.96 f

Description: Different superscripts on the same column indicate highly significant differences (P≤0.01) on the texture and WHC, and significant differences (P≤0.05) on L color.

The sausage brightness (L color) was not significantly different (Table 1) between each treatment. This showed that the different addition levels of elephant foot yam flour and soybean oil produced relatively similar sausage color, both for L, a*, and b* color. However, higher elephant foot yam flour addition tends to produce lower sausage brightness (L), while different soybean oil addition showed no observed effect on the sausage color.

In table 2, it can be seen that the interaction between elephant foot yam flour and soybean oil addition, with higher flour addition (20%) showed higher texture at all soybean oil concentrations in this research. This showed that the soybean oil hand an important role to maintain the protein emulsion stability to bind protein molecules (Mejia *et al*., 2018). The polysaccharides contained in elephant foot yam flour are starch and foot fiber. Kim *et al*. (2019) stated that konjac flour contained glucomannan which would increase viscosity, gel strength, and chewy texture of the sausage. Thus, the combination of starch, carrageenan, and gum could be used as fat analog for low-fat meat products (Jimenez-Colmenero *et al*. 2013). The soybean oil addition at up to 20% would reduce the WHC of the food product, however, the sausage WHC in this research remained stable due to the addition of elephant foot yam flour which has water absorption properties.

In this research, at 20% elephant foot yam flour and 20% soybean oil addition showed syneresis with the highest gel strength. Mejia *et al*. (2018) described that dispersed phase fat compounds on the protein-water solution would form emulsion like three-dimensional matrix as seen during microstructure observation (Figure 1). The microstructure observation of beef sausage with different elephant foot yam flour and soybean oil addition is presented in Figure 1. The A1, A2, and A3 in figure 1 showed the microstructure of beef sausage with 10% elephant foot yam flour addition and different soybean oil addition (10%, 15%, and 20%, respectively). The B1, B2, and B3 in figure 1 showed the microstructure of beef sausage with 15% elephant foot yam flour addition and different soybean oil addition, while C1, C2, and C3 in figure 1 showed the microstructure of beef sausage with 20% elephant foot yam flour addition and different soybean oil addition. The microstructure observation showed that the addition of elephant foot yam flour addition gave strong and firm gel protein, as seen in A1, B1, and C1. This indicates that 10% soybean oil addition could not dissolve all of the starch in the sausage mixture, as starch granules were not well dispersed, and form gel matrix due to the moisture deficiency. Different results were shown on 15% and 20% soybean oil addition, which had well-dispersed starch granule and pores throughout the beef sausage.

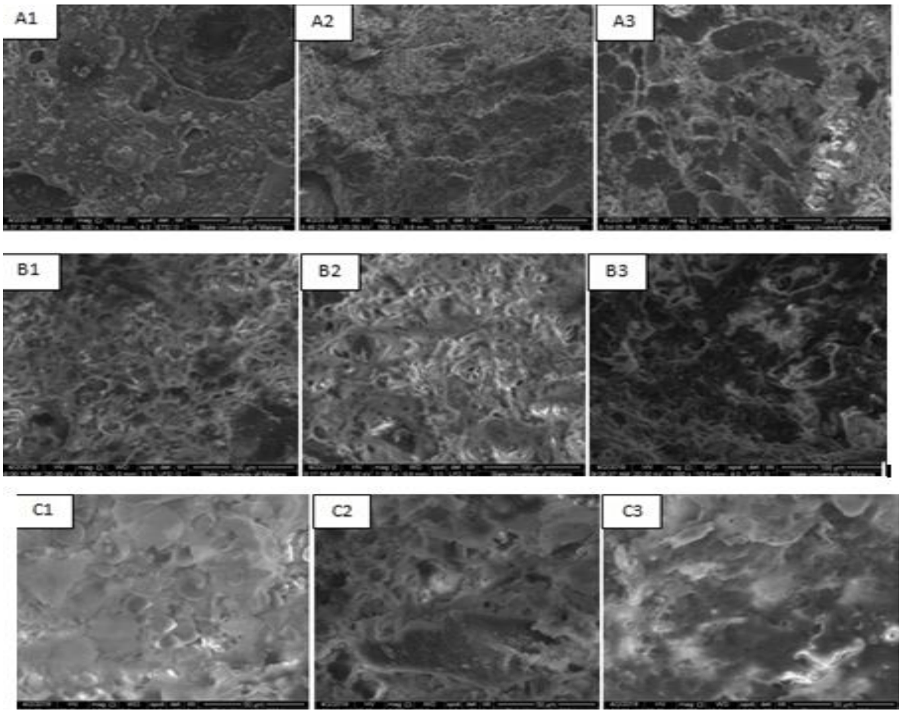

Figure 1. Microstructure of the beef sausage with different elephant foot yam flour (S) and soybean oil (L) additions. A1 (S10L10), A2 (S10L15), A3 (S10L20), B1 (S15L10), B2 (S15L15), B3 (S15L20), C1 (S20L10), C2 (S20 L15) and C3 (S20L20).

Proximate and dietary fiber

The moisture of beef sausage added with different levels of elephant foot yam flour and soybean oil is presented on Table 3. The results showed that higher elephant foot yam flour addition leads to higher moisture as well. The obtained results were correlated to the pH and WHC of the beef sausage. The added water was maintained by the flour and bound along with protein in the three-dimensional matrix system. However, higher soybean oil addition had negative effect to the sausage moisture, even though the addition of soybean oil as much as 20% showed beef sausage moisture at 66.42% and is still in accordance to the Indonesian standard for sausage product. According to Arildsen *et al*. (2014), the addition of fat compounds to the meat products could increase its overall palatability even though would change the products' texture into more porous and often caused syneresis, as happened with 20% soybean addition in this research. The addition of elephant foot yam flour showed highly significant differences ($P \leq 0.01$) to the protein content of beef sausage, with 20% flour addition showed the highest protein content. The results were due to the protein content of elephant foot yam flour (7.02%), thus higher flour addition would result in the higher protein content of beef sausage as well.

The protein content measurement is important as it would affect the formed gel strength, which when partially denatured, would be followed with irreversible three-dimensional matrix formation (Choi *et al*., 2011). Moreover, the results showed that the soybean oil addition did not give significant difference to the protein content (P>0.05). The addition of elephant foot yam flour showed significant effect (P≤0.05) to the fat content of beef sausage, with the highest fat content (9.46%) was found on 20% flour addition. The elephant foot yam flour in this research had 0.62% fat content, thus even though relatively small would affect the total fat content of the beef sausage. Furthermore, the elephant foot yam flour is high of polysaccharides, whether in the form of dietary fiber or crude fiber.

Table 3. Proximate and crude fiber analysis of beef sausage with different elephant foot yam flour (EFYF) and soybean oil (SBO) addition

Treatments	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude Fiber (%)
EFYF (%)					
10	67.39±8.18$_{a}$	10.67±0.40$_{a}$	9.06±8.95$_{a}$	1.09±0.06$_{a}$	0.91±0.12$_{a}$
15	68.82±6.04$_{ab}$	10.86±0.67$_{a}$	9.38±7.85$_{b}$	1.24±0.18$_{b}$	1.07±0.26$_{b}$
20	69. 63±5.81$_{b}$	11.04±0.82$_{ab}$	9.46±7.80$_{c}$	1.42±0.36$_{c}$	2.91±0.19$_{c}$
SBO (%)					
10	70.62±5.72$_{b}$	10.92±0.65	6.74±7.19$_{a}$	1.24±0.36	1.63±2.22
15	68.79±4.01$_{b}$	10.85±0.64	9.14±6.16$_{b}$	1.25±0.38	1.61±2.81
20	66.42±5.25$_{a}$	10.80±0.63	12.02±6.78$_{c}$	1.26±0.43	1.65±3.00

Description: Different superscripts on the same column indicate highly significant differences (P≤0.01) on the moisture and fat content of beef sausage with different SBO addition.
Different superscripts on the same column indicate highly significant differences (P≤0.01) on the ash, protein, and crude fiber content of beef sausage with different EFYF addition.
Different superscript on the same column indicate significant differences (P≤0.05) on the moisture content of beef sausage with EFYF addition.

Table 4. Interaction of elephant foot yam flour (EFYF) and soybean oil (SBO) addition to the fat and crude fiber content of beef sausage

Fat content interaction (%)		Crude fiber interaction (%)	
Treatments (%)	Mean	Treatments (%)	Mean
EFYF 10 SBO 10	6.12 $_{a}$	EFYF 10 SBO 15	0.86 $_{a}$
EFYF 15 SBO 10	6.89 $_{b}$	EFYF 10 SBO 10	0.92 $_{b}$
EFYF 20 SBO 10	7.19 $_{b}$	EFYF 10 SBO 20	0.94 $_{b}$
EFYF 10 SBO 15	8.96 $_{c}$	EFYF 15 SBO 10	1.04 $_{c}$
EFYF 20 SBO 15	9.20 $_{c}$	EFYF 15 SBO 15	1.06 $_{cd}$
EFYF 15 SBO 15	9.27 $_{c}$	EFYF 15 SBO 20	1.11 $_{d}$
EFYF 15 SBO 20	11.98 $_{d}$	EFYF 20 SBO 20	2.89 $_{e}$
EFYF 20 SBO 20	11.98 $_{d}$	EFYF 20 SBO 15	2.91 $_{e}$
EFYF 10 SBO 20	12.09 $_{d}$	EFYF 20 SBO 10	2.93 $_{e}$

Description: Different superscripts indicate significant differences (P≤0.05) on the fat and crude fiber content of beef sausage

Table 5. Soluble dietary, insoluble dietary, and dietary fiber content of beef sausage with different elephant foot yam flour (EFYF) addition

Treatments	Moisture (%)	SDF (%)	IDF (%)	Total DF (%)
EFYF 10%	6.63	2.12	16.19	18.30
EFYF 15%	6.85	2.22	16.77	18.98
EFYF 20%	7.32	2.71	17.21	19.92

Description: Soluble dietary fiber, IDF: Insoluble dietary fiber, DF: Dietary fiber.

Table 6. Amino acids content of beef sausage added with different elephant foot yam flour (EFYF) addition

Amino acids (%)	Beef	Sausage		
		EFYF 10%	EFYF 15%	EFYF 20%
Aspartate	1.39	1.02	1.07	0.95
Serine	0.75	0.39	0.33	0.32
Glutamate	2.87	2.06	2.62	1.88
Glycine	1.30	0.85	0.85	0.77
Histidine	0.72	0.47	0.35	0.38
Arginine	1.32	1.19	1.04	1.03
Threonine	1.21	1.08	0.90	0.93
Alanine	1.01	0.64	0.65	0.59
Proline	0.29	0.12	0.13	0.12
Cystine	0.90	0.54	0.61	0.37
Tyrosine	0.86	0.45	0.36	0.44
Valine	1.08	1.02	0.95	0.92
Methionine	0.74	0.34	0.28	0.31
Lysine	1.76	1.23	1.31	1.15
Isoleucine	0.99	0.91	0.82	0.80
Leucine	1.71	1.51	1.39	1.34
Phenylalanine	1.37	0.90	0.72	0.76

The addition of the flour would then increase the fiber content of the beef sausage. The flour addition would also increase the ash content of the beef sausage as elephant foot yam flour also had high ash content (10.86%). Andriansyah (2014) mentioned that fiber rich food would have higher digestibility. Qi *et al*. (2015) added that crude fiber is undissolved carbohydrate even when heated and solved with sulfuric acid and NaOH solution. Ash content analysis could then be done to determine the fiber content by subtracting the residual component after burned with the ash content (Septiani *et al*., 2015). The Duncan's test (Table 4) showed that the addition of elephant foot yam flour and soybean oil were interacted to affect the fat and crude fiber content of the beef sausage, yet the increased fat content were mostly affected by the added soybean oil levels. The similar results were also found with elephant foot yam flour and crude fiber content of the beef sausage.

In Table 5, it can be seen that 20% elephant foot yam flour addition had the higher dietary fiber (19.83% to 19.99%), thus showed the potetial of the flour utilization as functional food for human health.

Amino acid

Amino acids are the building blocks for protein, while the protein would determine the structure and texture of the produced beef sausage. The addition of elephant foot yam flour at 10%, 15%, and 20% with 10% soybean oil showed 17 detected amino acids in the sausage (Table 17), with valine, tryptophan, and glutamine were not found.

Aside from the elephant foot yam flour addition, other known factors which affect amino acids content were pH and temperature during processing. In this research, the temperature for sausage processing was at 80^{o}C for 20 min. Several heat susceptible amino acids would be then denatured and loss. The highest amino acids in the produced beef sausage were myofibril amino acids, such as glutamic acid, lysine, and leucine, while lysine is the most susceptible to the heat and showed higher decrease. The amino acid profile of the produced beef sausage with 10-11% protein content in this research are categorized as good quality meat products according to the Indonesian Standard Agency (BSN, 2015).

Table 7. Descriptive sensory analysis of beef sausage with different elephant foot yam flour (EFYF) and soybean oil (SBO) addition

Treatments	Texture	Aroma	Flavor
EFYF			
10	3.56 $_{a}$	3.71 $_{a}$	3.64 $_{a}$
15	4.11 $_{b}$	4.27 $_{b}$	4.13 $_{b}$
20	3.64 $_{a}$	3.56 $_{a}$	3.51 $_{a}$
SBO			
10	3.71 $_{a}$	3.84 $_{a}$	3.80 $_{ab}$
15	3.98 $_{b}$	3.89 $_{a}$	3.91 $_{b}$
20	3.62 $_{a}$	3.80 $_{a}$	3.58 $_{a}$

Description: Different superscripts on EFYF addition indicate highly significant differences ($P \leq 0.01$) on texture, aroma and flavor of the beef sausage
Different superscripts on SBO addition indicate significant differences ($P \leq 0.05$) on texture and flavor, but not on aroma of the beef sausage

Table 8. Interaction of elephant foot yam flour (EFYF) and soybean oil (SBO) addition to the sensory properties of beef sausage

Treatments	Texture	Aroma	Flavor
EFYF 10 SBO10	3.30 $_{ab}$	3.47 $_{ab}$	3.53 $_{ab}$
EFYF 10 SBO 15	3.60 $_{abc}$	3.60 $_{abc}$	3.67 $_{ab}$
EFYF 10 SBO 20	3.73 $_{bc}$	4.007 $_{cde}$	3.73 $_{bc}$
EFYF 15 SBO 10	3.93 $_{c}$	4.20 $_{de}$	4.13 $_{cd}$
EFYF 15 SBO 15	4.47 $_{d}$	4.53 $_{e}$	4.53 $_{d}$
EFYF 15 SBO 20	3.93 $_{c}$	4.07 $_{cde}$	3.73 $_{bc}$
EFYF 20 SBO 10	3.87 $_{c}$	3.87 $_{bcd}$	3.73 $_{bc}$
EFYF 20 SBO 15	3.87 $_{c}$	3.53 $_{ab}$	3.73 $_{bc}$
EFYF 20 SBO 20	3.20 $_{a}$	3.27 $_{a}$	3.27 $_{a}$

Description: Different superscripts indicate significant difference ($P \leq 0.05$) on the EFYF and SBO addition to the sensory properties of beef sausag

Sensory properties

In this research, the sensory properties (texture, aroma, and flavor) of the produced beef sausage were measured through organoleptic test. The obtained score for beef texture in this research were ranged from 3.5 to 4.1, with the highest score were obtained with 15% elephant foot yam flour and 15% soybean oil addition, which are categorized as chewy and acceptable. The addition of elephant foot yam flour showed significant effect ($P \leq 0.05$) on the aroma of beef sausage, with the obtained score were ranged from 3.5 (balanced flour and beef aroma) to 4.2 (had beef aroma), and overall score were accepted by the panelists.

The results indicate that the flour could be used as filling and binding agent for beef sausage as the addition could produce good texture and did not significantly change the beef aroma. The addition of soybean oil also did not affect the aroma of beef sausage, with the average aroma score was 3.8. Furthermore, the addition of elephant foot yam flour and soybean oil showed significant effect ($P \leq 0.05$) to the flavor of the beef sausage, with the average score were ranged from 3.5 (balanced beef and flour flavor) to 4.2 (beefy flavor). The highest flavor score of beef sausage in this research was obtained by the 15% elephant foot yam and 15% soybean oil addition.

In Table 8, it can be seen that there was significant interaction ($P \leq 0.05$) of elephant foot yam flour and soybean oil to the texture, aroma and flavor of the produced beef sausage. The most preferred beef sausage texture, aroma and flavor was obtained by the 15% elephant foot yam flour and 15% soybean oil addition. This showed that the addition of both ingredients at 15% concentration was able to maintain the preferred texture and prevent syneresis. Jimenez-Colmenero *et al.* (2010) stated that meat processed products should be made from fresh ingredients as it correlates with the water binding capacity on gel matrix. Other factors that should be noted are the added seasoning, fat or other hydrocolloids as the additions would affect the consumers' acceptability.

CONCLUSION

The research concludes that the addition of elephant foot yam flour and soybean oil addition affect the physicochemical properties of the beef sausage. The higher elephant foot yam flour and soybean oil addition showed better physical properties of the beef sausage, yet would be less preferred by the consumer.

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