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Physicochemical quality of beef sausage with the substitution of tapioca flour and kepok banana flour (*Musa paradisiacal formatypica*)

Kualitas fisikokimia sosis daging sapi dengan substitusi tepung tapioka dan tepung pisang kapok (Musa paradisiacal formatypica)

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ABSTRACT

This study aimed to evaluate the physicochemical quality of beef sausage made by replacing tapioca flour as an essential filler in sausage making with kepok banana flour. This study used a 4 × 5 randomized complete block design (CRD) pattern with a total of 20 experimental units. The variables tested included amylose, amylopectin, water holding capacity, hardness, and pH of the sausage. Data were analyzed using analysis of variance with SPSS 16 software and further tested using Duncan's method to see differences between treatments. The results showed that the amylose content of sausages ranged from 0.33±0.04 to 0.57±0.01%; amylopectin content ranged from 3.83±0.15 to 3.29±0.10%; water holding capacity ranged from 30.67±9.86 to 48.11±5.74%; pH ranged from 4.29±0.02 to 6.31±0.15, and hardness ranged from 1,271.5±56.8 to 2,261.75±71.7 g. The F3 treatment yielded the best results. The best results were shown in treatment F3 (15% kepok banana flour + 5% tapioca). The use of banana flour, up to 15% as a substitute for tapioca flour, can be used in making beef sausage.

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi kualitas fisikokimia sosis daging sapi yang dibuat dengan melakukan penggantian tepung tapioka sebagai bahan dasar pengisi pada pembuatan sosis dengan tepung pisang kepok. Penelitian ini menggunakan rancangan acak lengkap (RAL) pola 4 × 5 dengan jumlah 20 unit percobaan. Variabel yang diuji meliputi kadar amilosa, amilopektin, daya ikat air, kekerasan, dan pH sosis. Data dianalisis menggunakan analisis ragam dengan software SPSS 16, dan apabila berpengaruh nyata maka dilanjutkan dengan Duncan test. Hasil penelitian memperlihatkan bahwa kadar amilosa sosis berkisar antara 0,33±0,04 sampai 0,57±0,01%; kadar amilopektin berkisar antara 3,83±0,15 sampai 3,29±0,10%; daya ikat air berkisar antara 30,67±9,86 sampai 48,11±5,74%; pH berkisar antara 4,29±0,02 sampai 6,31±0,15; dan kekerasan berkisar antara 1.271,5±56,8 sampai 2.261,75±71,7 g. Hasil terbaik diperlihatkan pada perlakuan F3 (tepung pisang kepok 15% + 5% tapioka). Penggunaan tepung pisang kapok hingga 15% sebagai subtitusi tepung tapioka dapat dilakukan pada pembuatan sosis sapi.

Kata kunci:
Kualitas fisikokimia
Sosis daging sapi
Tepung pisang kepok

INTRODUCTION

Beef meat has an important role for humans because it contains protein that is good for human needs. Judging from its nutrition, animal protein has a better and more complete composition when compared to vegetable protein. Meat has a high nutritional value. Meat has a high nutritional value because it has complete and balanced amino acids (Soeparno, 2015). Meat is one of the foods with high nutritional value because it is rich in minerals, fat, protein, and other substances humans need. Efforts can be made to maintain the quality of beef by processing it so that damage or spoilage can be avoided.

One of the meat processing products is sausage, which is well known in the community. Currently, the need for food that is fast (ready to cook) is getting higher. Independent survey data conducted by private companies shows that sausage consumption by Indonesians is growing at an average rate of 4.46% per year. The raw materials used to make sausages consist of main ingredients and additional ingredients. The main ingredient is meat, while the additional ingredients are fillers, flavoring ingredients, and other permitted food ingredients (Soeparno, 2015).

In making sausages, the substitute material used is tapioca flour, which is a filling material. The function of tapioca flour substitution is to bind the meat so that it is more unified, to produce sausages that have a dense, chewy texture, and can bind restructuring materials that are determined by their ability to bind ingredients. Tapioca flour has a nutritional content per 100 g, namely 362 calories; 0.59% protein; 3.39% fat; 1.29% water content and 6.99% carbohydrates (Kusnadi, Bintoro, & Al-Baarri, 2012). The increasing price of tapioca flour due to high demand requires alternative food sources of local carbohydrates that can replace tapioca flour.

Banana fruit is a source of fiber, carbohydrates, and calcium. Banana flour processed using oven drying has a carbohydrate content of 88.60 g in the form of starch, glucose, dextrose, fructose, and sucrose. The protein content is about 1%, low fat, high in vitamins, and high energy (340 kcal/100 g) (Nurhayati & Andayani, 2014).

The benefits of banana fruit can be taken from the flour, which resembles tapioca used as sausage. According to Syafii, Fajriana, & Ma'rifatullah (2023), the amylose content in white kepok banana flour is about 19.2% and the amylopectin content is 80.8%. The starch content is similar to the starch content found in tapioca flour, namely: 17% of amylose and 83% of amylopectin (Rahman & Mardesci, 2015). So it is thought that kapok banana flour could be used as a substitute for tapioca flour. The background description above suggests that adding kepok banana flour and tapioca flour substitution to sausages will replace tapioca flour as a filling material to bind the meat and make it more cohesive, resulting in sausages with a dense and chewy texture.

MATERIALS AND METHODS

Tools and Materials

The tools used in this study consisted of a stuffer, food processor (Idealife brand), cutting board, sleeve, rope, thermometer, digital scale (Acis), pH meter (Hanna, USA), oven (Binder), knife, stove, pot, and spoon. The ingredients used were beef, kepok banana flour (Hasil Bumiku), tapioca flour, salt, flavoring, garlic, skim milk, pepper, corn oil, eggs, and ice cubes.

Research Design

This study used a completely randomized design (CRD) consisting of 5 treatments and 4 replicates with 20 treatment units. The treatments were as follows: F0: kepok banana flour 0% + 20% tapioca (control), F1: kepok banana flour 5% + 15% tapioca, F2: kepok banana flour 10% + 10% tapioca, F3: kepok banana flour 15% + 5% tapioca, and F4: kepok banana flour 20% + 0% tapioca.

Research Procedure

Beef that has been cut into small pieces and cleaned of connective tissue is then finely ground using a grinder or food processor. Ingredient composition for making sausage dough. Then seasonings, ice cubes, and treatments with varying concentrations of each dough were combined according to Table 2 and ground again for 1 minute. The dough in Table 1 was then added to skim milk, mixed, and pulverized for 1 minute. After the second mashing stage, the dough was added to corn oil and then mashed again for 1 minute. The dough is again put into the stuffer and into the casing. Once stuffed, tying the sausage casings at the edges every 10 cm is necessary. The sausages were processed at 100°C for 30 minutes using the steaming cooking method. The sausages were then removed and aerated for further testing. Repetitions were conducted four times for each treatment.

Observed Variables

The variables observed in this study were: amylose content, amylopectin content, water holding capacity, hardness, and pH of the sausage.

Amylose Content

A sample weighing 1.5 g was put into a scaled tube, and then 7.5 ml of distilled water

Table 1. Ingredients for making beef sausage

Ingredients	Percentage
Beef	200 g
Ice Water	80 ml
Corn Oil	32 ml
Skim Milk	16 g
Salt	4 g
Sugar	2 g
Pepper	1 g
Yolk Eggs	2 g

Table 2. Treatment combination of kepok banana flour and tapioca flour

Combination	Treatment				
	F0	F1	F2	F3	F4
Kepok Banana Flour	0%	5%	10%	15%	20%
Tapioca Flour	20%	15%	10%	5%	0%

F0: control (0% kepok banana flour +20% tapioca), F1: 5% kepok banana flour + 15% tapioca, F2: 10% kepok banana flour + 10% tapioca, F3: 15% kepok banana flour + 5% tapioca, F4: 20% kepok banana flour + 0% tapioca.

was added. The mixture was homogenized using a vortex. The mixture was centrifuged for 15 minutes and then separated between the precipitate and the supernatant. The supernatant was brought to a boil on a hot plate. The sample was centrifuged for 15 minutes. The sample was separated from the supernatant for testing, then 2 ml of the supernatant was taken and 1 ml of a 10% TCA solution was added. The solution and precipitate were then separated by centrifugation for 15 minutes. TCA sample extract, as much as 0.1 ml, was added to 1.9 ml of distilled water and 2.5 ml of Lowry reagent. The mixture was homogenized and kept at room temperature for 10 minutes. Next, 0.5 ml of folin reagent was added and incubated at room temperature for 30 minutes until a blue color was formed. The absorbance of the sample was measured on a spectrophotometer with a wavelength of 600 nm using a standard Bovine Serum Albumin (BSA) solution (AOAC, 2005).

Amylopectin Content

How to calculate the starch content by knowing the difference between the titration of the blank and the titration of the sample. The reduction in sugar content after inversion (after being hydrolyzed with 25% HCl) in the material can be found by using the table of the difference between the inverse sugar content and before inversion multiplied by 0.9, which is the starch content in the material (AOAC, 2005).

$$\text{Starch content (\% bw)} = \frac{\text{mg glucose x FP x 0.9 x 100\%}}{\text{mg starch sample}}$$

Details:
mg glucose : Luff Schoorl table number, based on the difference in ml titration.
FP : ml filtrate titration.

Amylopectin (% bw) = Starch content (% bw) – Amylose content (% bw)

Water Holding Capacity

Testing the water holding capacity of sausage samples begins with preparing a 0.3 g sample. The 0.3 g sausage was placed between two Whatman filter papers, then pressed in a copper press tool to a pressure of 35 kg/m^2 for 5 minutes. After the sausage in a pile of filter paper has become a slab-like mold, measure the area using a centimeter block. Next, the moisture content of the sausage was measured. The moisture content of sausage was measured by weighing 1 g of sausage, then put into a porcelain cup and weighed again. The porcelain cup containing the sample was dried in an oven at 105°C for 24 hours until a constant dry weight was obtained. The porcelain cup containing the sample was then cooled in a desiccator for 5 minutes and weighed (Soeparno, 2015). Calculation of water holding capacity of sausages using the following formulas:

Wet area formula

Wet Area = Outside area – Inside Area

After getting the wet area measure the mgH_2O contained:

$$mgH_2O = \pi r \frac{\text{Wet Area (cm)}}{0.0948} - 8{,}0$$

Description: 0.0948 = formula constant mgH_2O

Water content formula

$$\text{Water content} = \frac{[B-(C-A)]}{B} \times 100\%$$

Description:
A : cup weight
B : fresh sample weight
C : cup weight + sample after oven

The formula for calculating water holding capacity:

Water holding capacity (%) = Fixed moisture content (%) – Free water content (%)

Hardness

The hardness can be analyzed with a texture analyzer (CT3) from Brookfield. Ensure that the electric current is on and the texture analyzer is in good condition. Then, connect the fitting to the electric current. Then the deformation is set, speed is triggered, and the ON (-) button on the back of the texture analyzer is pressed. Sausage elasticity was analyzed using a 5.0 g trigger, 10.0 mm deformation, and 3.0 mm/s speed. Install the probe tool according to the material being tested. The probe used is a cylindrical probe type with a diameter of 1 cm. Press the reset button as desired. The material is tested right at the bottom of the probe. Press the start button to continue. The probe moves down and hits the material. Record the number of results (final load) listed on the tool. Press the stop button when finished (AOAC, 2005).

Value of pH

The hydrogen potential value (pH) was measured at room temperature using a pH meter. Before immersion in the sample, calibration is first carried out using pH 4 and pH 9. After completing the calibration, the pH meter is dipped in the sample. The value read is recorded as the pH of the sample (AOAC, 2005).

Data Analysis

Data were analyzed using analysis of variance and processed with SPSS 16 software. Treatments that showed an effect (P>0.05), were further tested using Duncan's method to see differences between treatments (Steel & Torrie, 1993).

RESULT AND DISCUSSION

Chemical Quality

The chemical quality of beef sausage includes the average activity of the percentage value of amylose and amylopectin content. Amylose is a starch component with a straight chain and is soluble in water, while amylopectin has a branch chain and is insoluble in n-butanol. Amylose itself plays a role in increasing complex properties, and amylopectin plays a role in forming viscosity and stickiness in food products (Wibowo, Saputra, Ayucitra, & Setiawan, 2008).

Amylosa Content

The analysis showed that adding tapioca flour and banana flour had a significant effect (P<0.05) on the amylose content of beef sausage. Table 3 shows there was an increase in amylose content in line with the increasing percentage of the use of kepok banana flour, with the highest values seen in the F3 and F4 treatments at 0.57 and 0.55%, respectively. This is due to the higher amylose content in banana flour than in tapioca flour. The percentage of amylose content in banana flour is around 19.2% (Syafii et al., 2023), while the rate of amylose content in tapioca flour is 17% (Syamsir, Hariyadi, Fardiaz, Andarwulan, & Kusnandar, 2011).

The study's results using the substitution of banana flour with tapioca flour produced lower amylose levels than those using banana onggol flour (Dethan, Sabtu, & Riwu, 2022). The average amylose content of chicken sausage was 2.8%. The low amylose content is likely due to the denaturation of starch content in tapioca flour and banana flour due to high temperatures around ± 100°C. When starch is heated, some amylose molecules will come out of the starch granules and dissolve in water. In the opinion of Jayaputri (2019), starch bound to water will evaporate during steaming, so if a lot of water content is released, the starch content will be released along with water vapor. In the research of Dethan et al. (2022), the substitution of kepok banana hump flour has an impact on reducing the amylose content of chicken sausage. Research on the characteristics of beef sausage with the addition of red sorghum produced amylose levels of 3.41% with a substitution of 50% sorghum flour and 50% tapioca flour (Emu, Sabtu, & Armadianto, 2020).

Table 3. Mean chemical quality of beef sausage with the addition of tapioca flour and banana flour

Treatment	F0	F1	F2	F3	F4
Amylose (%)	0.33 ± 0.04[a]	0.37 ± 0,11[ab]	0.47 ± 0.03[bc]	0.57 ± 0.01[c]	0.55 ± 0.10[c]
Amylopectin (%)	3.83 ± 0.15[a]	3.98 ± 0,13[a]	3.41 ± 0,09[b]	3.34 ± 0.08[b]	3.29 ± 0.10[b]

Different superscripts on the line indicate significant differences (P<0.05). F0: Control (0% kepok banana flour +20% tapioca), F1: 5% kepok banana flour + 15% tapioca, F2: 10% kepok banana flour + 10% tapioca, F3: 15% kepok banana flour + 5% tapioca, F4: 20% kepok banana flour + 0% tapioca.

Amylopektin Content

The analysis showed that adding tapioca flour and banana flour had a significant effect (P<0.05) on the amylopectin content of beef sausage. Table 3 shows that the highest amylopectin content was seen in F0 (the control treatment), then there was a decrease in amylopectin content in treatments F3 and F4. The analysis showed that adding tapioca flour and banana flour had a significant effect (P<0.05) on the amylopectin content of beef sausage. Table 3 reveals that the control treatment, F0, had the highest amylopectin content, while treatments F3 and F4 showed a decrease in amylopectin content. The higher the percentage of banana flour, the lower the amylopectin content. This is due to the low amylopectin content of banana flour compared to tapioca flour. If tapioca flour is not substituted with banana flour, the amylopectin content of the sausage remains high. Syamsir et al. (2011) state that tapioca flour contains 83% amylopectin with a granule size of 3–3.5 μ, so that the water absorption process during cooking also increases. According to Yuliana & Novitasari (2014), the amylopectin content in kepok banana flour is lower than tapioca flour, which is 79.5%. Research on substituting tapioca flour with kepok banana hump flour conducted by Dethan et al. (2022) produced an amylopectin content in chicken meat sausage of 17.30%.

High amylopectin levels cause increased gelatinization, and vice versa, low amylopectin levels cause low water holding ability. This is in line with the opinion of Rahman & Mardesci (2015) that amylopectin has more hydroxyl groups than amylose, so that amylopectin has a higher ability to bind and retain water. The higher amylopectin content in starch will cause more water to be trapped.

Physical Quality

Water Holding Capacity

Water holding capacity (WHC) is the ability of meat to maintain water content during treatment, such as cutting, heating, grinding, and processing. The analysis showed a significant difference (P<0.05). Table 4 shows that the highest amylopectin content was seen in the F3 treatment. Water holding capacity (WHC) is the ability of meat to maintain water content during treatment, such as cutting, heating, grinding, and processing. The analysis showed a significant difference (P<0.05). Table 4 reveals that the F3 treatment exhibited the highest amylopectin content. The water holding capacity of the sausage increased with the addition of kepok banana flour. This is due to the high amylose content in kepok banana flour compared to tapioca flour, which causes the water holding capacity of the sausage to increase. This is due to the high amylose content in kepok banana flour compared to tapioca flour, which causes the water holding capacity of the sausage to increase. According to Wibowo et al. (2008), the amylose content of white kepok banana flour is about 19.2% and the amylopectin content is 80.8%. Amylopectin is the insoluble fraction, while amylose is the soluble fraction. The amylose component affects the formation of a strong and stiff gel, and amylose has hydration properties that can bind water molecules to form an elastic mass. According to Soeparno (2015), the high starch content of flour will absorb more water.

The starch content in tapioca flour and kepok banana flour affects the ability to prevent the release of water in sausage products. The water holding capacity value of chicken sausage with the addition of carrageenan and transglutaminase produces a water holding capacity value of 60.72% (Ismanto, Lestyanto, Haris, & Erwanto, 2020). This value is higher than the results of this study because the nature of carrageenan has a significant water holding capacity value. The type of meat, muscle type, pH, and chemical composition of the meat, along with the ingredients added to the ground meat, also determine the water holding capacity.

Table 4. Average physical quality of beef sausage with the addition of tapioca flour and banana flour

Physical Quality	F0	F1	F2	F3	F4
Water Holding Capacity (%)	30.67 ± 9.86[a]	45.61 ± 1.88[b]	42.37 ± 4.33[b]	48.11 ± 5.74[b]	45.20 ± 2.03[b]
Value of pH	6.31 ± 0.15[a]	5.10 ± 0.04[b]	4.39 ± 0.02[c]	4.40 ± 0.04[c]	4.29 ± 0.02[c]
Hardness (g)	1,271.5 ± 56.8[a]	1,522.37 ± 337.2[a]	1,430.02 ± 151.0[ab]	1,813.75 ± 374.3[b]	2,261.75 ± 71.7[c]

Different superscripts on the line indicate significant differences (P<0.05). F0: Control (0% kepok banana flour + 20% tapioca), F1: 5% kepok banana flour + 15% tapioca; F2: 10% kepok banana flour + 10% tapioca; F3: 15% kepok banana flour + 5% tapioca; and F4: 20% kepok banana flour + 0% tapioca.

Value of pH

The pH value is one of the physical characteristics of sausage that shows the level of basicity of the sausage product. The analysis showed a significant difference (P<0.05) in the pH value of beef sausage, which ranged from 4.29 to 6.31. Table 3 shows that the highest pH value was seen in the F0 (control) treatment. The higher the concentration of kepok banana flour, the lower the pH of the sausage. The pH value is one of the physical characteristics of sausage that shows the level of basicity of the sausage product. The analysis showed a significant difference (P<0.05) in the pH value of beef sausage, which ranged from 4.29 to 6.31. Table 3 shows that the highest pH value was seen in the F0 (control) treatment. The higher the concentration of kepok banana flour, the lower the pH of the sausage. This is due to the addition of banana flour, which is acidic at around 4.6, so the increase in banana flour concentration will further reduce the pH of the sausage. The pH test results are in line with the results of the water holding capacity of the sausages (Table 4). It can be seen that the lower the pH of the sausage, the more its water holding capacity will increase. According to Soeparno (2015) at pH conditions higher or lower than the isoelectric point of meat proteins, water holding capacity will increase due to a pH that is higher or lower than the pH of the isoelectric point of meat proteins, resulting in charged meat molecules that will repel each other, causing empty spaces for water molecules.

The results of this study are in line with the results of previous studies. Untreated raw kepok banana flour produced a pH of 4.68 (Ekafitri, Surahman, & Afifah, 2016). The pH value of chicken sausage with carrageenan and transglutaminase produced a pH of 5.6 (Ismanto et al., 2020). The pH value of beef sausage with soy protein flour averages about 5.7 (Gomezulu & Mongi, 2022).

According to Soeparno (2015), the pH of ultimate meat ranges from 5.3 to 5.8 and increases slightly due to processing factors and the addition of other ingredients, such as binders and seasonings. The grinding process will cause damage to meat protein bonds, which will facilitate changes in the position of H+ and OH- ions during cooking. This change in isoelectric point causes the pH to change. A high pH value will result in a product with low cooking shrinkage and a softer texture (Bulkaini, Kisworo, & Yasin, 2019).

Hardness

According to Soeparno (2015), the hardness value indicates the amount of pressure that can destroy a product. The level of hardness is one of the determinants of the quality of processed meat products that are critical to consumer acceptance, and usually consumers want tender processed meat products. The analysis showed a significant difference (P<0.05) in the hardness value of beef sausage. Table 4 shows that the highest hardness value was seen in the F4 treatment. The fat content in tapioca flour and kepok banana flour is low; the fat content also affects firmness. A high fat content makes the sasage more tender. According to Desiliani, Harun, & Fitriani (2019), the fat content of kepok banana is 0.52%; according to Malini, Arief, & Henny (2016), the fat content of tapioca flour is 0.34%. Because banana flour has a higher fat content than tapioca flour, the sausages made with banana flour have a lower hardness.

The hardness of beef sausage is related to the fat content of the flour used. Fat gives the sausage tenderness, and the lower the fat, the harder the texture of the sausage (Samuel & Peerkhan, 2020). The higher the amount of tapioca flour and kepok banana flour, the harder the resulting sausage product will be. It can also be seen that the level of sausage hardness in treatment F3 is not different from F2, so the use of banana flours up to 15% in sausage making can still be done and does not really affect the level of sausage hardness.

According to Dethan et al. (2022), the hardness value of 1,008.38 g in the beef sausage research is higher than that of the chicken sausage research using banana hump flour.

Due to the use of beef as the primary ingredient in sausage making, this value is lower than the study's results. This is based on the opinion of Beniwal, Singh, Kaur, Hardacre, & Singh (2021) that the protein structure of beef is generally more sturdy and rigid than the protein structure of chicken meat. Chicken meat generally has thin and dense muscle fibers with soft tissue. In addition, the factor that causes the high hardness of sausages with the addition of banana flour is due to the high carbohydrate content of banana flour and the fat content of banana flour.

CONCLUSIONS

This study showed that the best treatment was shown in treatment F3 by making beef sausage using a combination of 15% kepok banana flour + 5% tapioca flour. This proves that kepok banana flour can be used as a substitute for tapioca flour by up to 15% in beef sausage making.

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