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Physical, Chemical, and Sensory Characteristics of Chicken Sausage with Analog Meat Substitution

Karakteristik Fisik, Kimia, dan Sensorik Sosis Daging Ayam dengan Substitusi Daging Analog

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Abstract

This research was conducted to make chicken sausage substitution using analog meat from gluten, soy protein isolate, wheat flour, *Anjasmoro* soybean, and *gembili* tuber flour to reduce chicken meat used and produce sausages with the same quality. The purpose of this study was to determine the sausage's physical, chemical, and sensory properties. The formulation of chicken sausage with analog meat substitution used a completely randomized design method with a single factor (chicken meat and analog meat ratio), with five treatments and each treatment was repeated three times. The five treatments are P1 = 90% chicken meat : 10% analog meat, P2 = 80% chicken meat : 20% analog meat, P3 = 70% chicken meat : 30% analog meat, P4 = 60% chicken meat : 40% analog meat and P5 = 50% chicken : 50% analog meat. The results showed that the substitution of chicken meat with analog meat had a significant effect on the physical, chemical, and sensory properties of chicken sausage. The results show that 70% chicken meat and 30% analog meat is the best treatment.
Keywords: analog meat, chicken sausage, substitution

Abstrak

Penelitian ini dilakukan untuk membuat substitusi sosis daging ayam menggunakan daging analog dari gluten, isolat protein kedelai, tepung terigu, kedelai Anjasmoro dan tepung umbi gembili. Sehingga dapat mengurangi penggunaan daging ayam dan dapat menghasilkan sosis dengan kualitas yang sama. Tujuan dari penelitian ini adalah untuk menentukan sifat fisik, kimia dan sensorik sosis. Formulasi pembuatan sosis daging ayam dengan substitusi daging analog, menggunakan metode rancangan acak lengkap dengan faktor tunggal (rasio penambahan daging ayam dan daging analog) dengan lima perlakuan serta masing - masing perlakuan diulang tiga kali ulangan. Lima perlakuan tersebut ialah P1 = 90% daging ayam : 10% daging analog, P2 = 80% daging ayam : 20% daging analog, P3 = 70% daging ayam : 30% daging analog, P4 = 60% daging ayam : 40% daging analog dan P5 = 50% daging ayam : 50% daging analog. Hasil penelitian menunjukkan bahwa susbtitusi daging ayam dengan daging analog berpengaruh nyata terhadap sifat fisik, kimia, dan sensorik sosis ayam. Hasil penelitian menunjukkan bahwa perlakuan70% daging ayam dan 30% daging analog adalah perlakuan terbaik.
***Kata Kunci**: daging analog, sosis daging ayam, substitusi*

INTRODUCTION

The lifestyle of modern society tends to prefer fast food. This lifestyle has become a habit because of the increasing demands for work (Lestari & Zamralita, 2017). One of the fast-food products favored by the public is chicken sausage. However, there are obstacles in consuming chicken meat, apart from the relatively high price. Some circles of society also desire to reduce the consumption of chicken meat (Kawata & Kubota, 2018). Excessive consumption of chicken sausage negatively impacts the human body. Processed chicken sausages contain high enough cholesterol and sodium so that they potentially cause heart disease, stroke, and hypertension if excessively consumed (Milicevic et al., 2014). Therefore, it is necessary to substitute meat sausage with analog meat from vegetable protein ingredients.

Analog meat can be made from a combination of various ingredients that have vegetable protein, including gluten, soy protein isolate (SPI), *Anjasmoro* soybean flour, and *gembili* tuber flour. Gluten has a chewy texture like meat and is non-cholesterol (Joshi and Kumar, 2015). Also, gluten functions as structure-forming analog meat. The high protein content in SPI functions as a water and oil binding agent (Mentari, Anandito, & Basito, 2016). The interaction between carbohydrates and proteins present in these materials results in shear forces that can form matrix tissues and increases the chewability and texture of analog meat such as real meat (Dekkers, Boom, & van der Goot, 2018). So, if chicken sausage is substituted with analog meat, it will not reduce the quality of the sausage itself.

Anjasmoro soybean flour and *gembili* tuber flour can also be used as an alternative to analog meat raw materials. *Anjasmoro* soybean is a superior variety that has a high protein content up to 42.1% (Gozalli et al., 2015). In addition to the use of *Anjasmoro* soybean flour, analog meat sausage can also be added with *gembili* tuber flour. The function of *gembili* tubers is to lower the bad cholesterol and increase good cholesterol in the human body (Herlina et al., 2015). Comprehensive information about chicken sausage with analog meat substitution is still not widely found. Therefore, this research was conducted to make sausages from chicken meat with analog meat substitution in physical, chemical, and sensory characteristics.

METHODS

Tools and Materials

Anjasmoro soybean flour production used a bowl, baking sheet, oven, and 60-mesh sieve. In sausages production, the utensils include a basin, spoon, analytical scale (Ohaus), 100 ml measuring cup, baking sheet, and steaming pan. The equipment needed for physical and chemical characteristics test includes color reader Minolta CR-10, Rheotex type SD 700, analytical scales (Ohaus), the crucible, oven (Memmert), desiccator, glass spatula, an ashing furnace (Nabertherm), filter paper (Whatman 4), soxhlet, Kjeldahl flask, Buchi distillation, fume hood, burette, 1 ml and 10 ml graduated pipette (Pyrex), 100 ml graduated cylinder (Pyrex), 250 ml beaker glass (Pyrex), 250 ml, and 500 ml Erlenmeyer (Pyrex), glass funnel, bulb pipette, and dropper pipette. The tools used for organoleptic tests include 25 sheets of organoleptic tests assessment, plates, knives, and flakes.

The main ingredients used in chicken sausage production with analog meat substitution are chicken meat, gluten, SPI, *Anjasmoro* soybean flour, *gembili* tuber flour, and ice water. Seasonings and food additives used in the sausages production are garlic, salt, and sodium tripolyphosphate (STTP). Materials used in chemical analysis are 95% ethanol, 95% alcohol, hexane solvent, pepsin, pancreatin, H_2SO_4 (Merck, Pa), Acetone, Selenium (Merck, Pa), Aquadesh, Indicator Methyl Red and Methyl Blue, 4 M HCl. (Merck, Pa), Boric Acid (H_2BO_3), NaOH (Merck, Pa), H_2SO_4 (Merck, Pa). Other materials used include aluminum foil, sausage casings, and thread.

Research Stages

<u>The Production of *Anjasmoro* Soybean Flour, Chicken Meat Puree, and Analog Meat Dough</u>

In the *Anjasmoro* soybean flour production, the first step is sorting the soybean seeds to separate the damaged soybeans and other objects found. The soybeans were washed with water to remove dirt, then soaked with a 3:1 ratio of water to soybean for 8 hours (water changed every two hours). This soaking process aimed to increase soybean imbibition, making it more tender and easy to grind. Soaked soybeans then boiled for 20 minutes to activate the lipoxygenase enzyme, which causes an unpleasant odor, and then drained. The drained soybeans are then dried under the sunlight for 4 hours and continued in an oven at 60 °C for 24 hours, then milled using a grinding machine. The milled soybeans are then sieved using a 60-mesh sieve. The *Anjasmoro* soybean flour is ready to be used as raw material for analog meat.

In chicken meat puree production, the first step is washing the chicken meat to remove any dirt. Then chicken meat is cut into small pieces. The grinding process is carried out by adding ice water in the ratio of 1.5 part of ice water to 1 part of chicken meat. This added ice water is to prevent protein denaturation due to friction during grinding.

In analog meat production, the initial step is to mix all the ingredients based on the analog meat formulation consisting of gluten, SPI, *Anjasmoro* soybean flour, and *gembili* tuber flour with a ratio of 5: 3: 1.5: 0.5 in a row. Then the ingredients are mixed in one container with a spoon until homogeneous so that the analog meat dough is ready to be mixed with chicken meat puree.

<u>Formulation and Analog Meat-Substituted Chicken Sausages Production</u>

The formulation of chicken sausage with analog meat substitution used a Completely Randomized Design (CRD) with a single factor: the ratio of chicken meat and analog meat addition, with five different treatments. Each treatment was repeated three times. The five variations of treatment are as follows:

1. P1 = 90% chicken meat : 10% analog meat
2. P2 = 80% chicken meat : 20% analog meat
3. P3 = 70% chicken meat : 30% analog meat
4. P4 = 60% chicken meat : 40% analog meat
5. P5 = 50% chicken meat : 50% analog meat

The sausage production begins with mixing the chicken puree and analog meat dough. 50% water, 2% garlic, 2% salt, 0.75% STTP and 15% tapioca added from the total weight of chicken meat and analog meat mixture. Then mix evenly using a mixer for 5 minutes at the lowest speed. The mixed dough is then put into a ±15 cm sausage casing, steamed at 80 °C for 30 minutes, then the sausages are ready to be served.

<u>Sausages Physical, Chemical and Organoleptic Test</u>

Tests conducted on products include physical properties (color, texture), chemical properties (moisture, ash, fat, protein, carbohydrate, and total fiber content), and organoleptic tests.

1. Physical Analysis

a. Color Brightness (Color Reader Minolta CR-10)

The color reader is used to determine the brightness (L) of the sausage. The color reader works based on the measurement of the sausage surface color reflection. Before using the color reader, standardization was carried out using white porcelain, while the standard value was L = 94.35; a = -5.75; and b = 6.51. The color reader standardization is done by placing the color sensor on the white porcelain by pressing the "Target" button. The values of L, a, and b appear, then for the brightness test of the sample color, the lens is affixed to the sample surface in an upright position, then the measuring button is pressed, then the value that appears is recorded. The L (Lightness) value corresponds to the degree of brightness, which ranges from 0 (black) to 100 (white). Brightness is stated to increase with increasing L value. Color brightness is obtained based on the following formula:

$$L = \frac{\text{Average Value of L at 3 points x 94.35}}{\text{Standard porcelain L value}} \quad (1)$$

where,
Standard provision for porcelain = 94.35
Standard L (L value for used porcelain)

b. Texture (Rheotex SD 700)

The sausage sample texture was measured using a Rheotex SD 700. The procedure is to press the power button first and adjusts the distance button to determine the depth of the needle when penetrating the sample. The depth of the needle used to measure the texture of the sausage is 5 mm deep. The following procedure is pressing the hold button, and the sample is placed on the sample holder just below the needle. Press the start button and wait for the needle to puncture the sample with a depth of 5 mm. The scale read on the tool is the texture of the sample expressed in units of grams/mm. Then the scale listed is recorded as X_1. Measurements were made five times at different points in each sample. So that the scale listed is recorded as X_1, X_2, X_3, X_4 and X_5 in one test sample and is calculated using the following formula:

$$\text{Texture} = \left(\frac{\text{gram}}{5\text{ mm}}\right) = \frac{X_1 + X_2 + \ldots X_5}{5} \quad (2)$$

c. SEM (Scanning Electron Microscopy) TM 3000

Turn on the equipment by pressing the power button on the right side of the main unit. Voiding will start automatically when the EVAC LED (blue) on the display panel is blinking. When the AIR LED lights up (yellow), press the EVAC/AIR button to start vacuuming. The EVAC LED lights up (blue) when the void ends. Prepare the sausage sample, then place it on the sample support, and adjust the distance between the surfaces with a height of 1 mm. Next, press the EVAC/AIR button to introduce air into the sample chamber. After the air is infused into the sample chamber, the AIR LED status (yellow) changed from blinking to light (about 1 minute). Enter the sample slowly by adjusting the sample support to the main unit. Then adjust the position of the sample surface you want to see by turning the XY button; its position can be seen on the display screen. Furthermore, a 1500x magnification was performed on each observation of the sausage sample.

2. Chemical analysis

a. Moisture content (Thermogravimetric Method, Association of Official Analytical of Chemist, 2005)

Analysis of water content was carried

out using the oven method (Thermogravimetry). The first step is to dry the porcelain plate at 100 -105 °C for 30 minutes and then put it in a desiccator for about 15 minutes and weigh it as (a) gram weight. Sausage samples were weighed 2 grams and put into a plate; the sample weight and plate were recorded as (b) gram. The plate containing the sample is put in an oven at 100 – 105 °C for 6 hours. After in the oven for 6 hours, the plates were put in a desiccator for 15 minutes and weighed until a constant weight was obtained, then recorded as (c) grams. The water content calculation formula is:

$$\% \text{ Moisture} = \frac{b - c}{b - a} \times 100\% \quad (3)$$

where,
a = empty cup weight (gram)
b = plates and samples weight (grams) prior to heating using oven
c = plates and samples weight (grams) after heating using oven

b. Ash content (Direct Method, Association of Official Analytical of Chemist, 2005)

The ash content analysis was carried out by ashing the sample in the furnace. The principle of this analysis is the combustion or ashing of organic materials, which are broken down into water and carbon dioxide, but inorganic substances do not burn. These inorganic substances are called ash. The first stage is the porcelain ash plate used, first drying it in an oven for 60 minutes at a temperature of 100-105 °C, then cooling it in a desiccator for 15 minutes and weighed.

The sausage sample was weighed 2 grams and put in an ashing cup which would be averaged over a Bunsen flame until it no longer smoked. The sample and plate weights were recorded as b grams. After that, put it in an ashing furnace with a temperature of 70 °C for 6 hours until the ashing is entirely complete. The ashing process is carried out until the ash is white. Furthermore, the sample was cooled beforehand for 12 hours. After that, the plates were put in a desiccator for 15 minutes, then weighed as weight c grams, until a constant weight was obtained. The calculation of the ash content is as follows:

$$\% \text{ Ash Content} = \frac{c - a}{b - a} \times 100\% \quad (4)$$

where,
a = empty cup weight (gram)
b = plate and sample weight (grams) before sowing
c = plates and sample weight (grams) after being sown

c. Fat Content (Shoxlet Method, Association of Official Analytical of Chemist, 2005)

Fat content was measured using the Soxhlet method. The fat flask is preheated for 30 minutes at a temperature of 100-105 °C and then cooled in a desiccator for 15 minutes, weighed and expressed as (a) gram. Then 2 grams of sausage samples were weighed and wrapped in filter paper that had been heated in the oven, then tied and weighed and expressed as (b) grams.

Then the oven process was carried out for 24 hours, with a temperature of 60 °C. After the oven process, it was put into the Soxhlet extraction equipment. Then the hexane solvent is poured until the sample is submerged. Fat extraction is carried out for 5 - 6 hours until the fat solvent is clear. The boiling flask containing the extraction is dried in an oven at 105 °C for 2-3 hours, then cooled in a desiccator for weighing and expressed as c grams. The drying stage of the fat flask was repeated until a constant weight was obtained. Fat content is calculated using the following formula:

$$\% \text{ Fat Content} = \frac{c - a}{b} \times 100\% \quad (5)$$

where,
a = boilling flask weight (grams)
b = sample weight (grams)
c = boilling flask and sample weight after oven (grams)

d. Protein Content (Semimicro-Kjehdal Method)

The stages of protein analysis consist of three stages: degradation, distillation, and titration. Measurement of protein content was carried out using the semi-micro-Kjeldahl method. The sausage sample was weighed as much as 0.5 grams, then put into a 100 ml Kjeldahl flask, then added 0.9 grams of selenium and 2 ml of concentrated H_2SO_4. Then the solution is heated at a temperature of 410 °C for approximately 1 hour until the solution is clear and then cooled. After chilling, 5 ml of distilled water and 20 ml of 40% NaOH were added to the Kjeldahl flask. Then the distillation process was carried out with a distillation temperature of 100 °C.

The distillation results are collected in a 125 ml Erlenmeyer flask containing a mixture of 15 ml of 4% boric acid (H_3BO_3), two drops of methyl red and methyl blue. After the distillate volume reaches 40 ml and is bluish-green, the distillation process is stopped. The distillate is irritated with 0.1 N HCl until it changes into pink color. The titrant volume is read and recorded. Then make a blank solution in the same way without the sample. Protein content was analyzed by the following formula:

$$\% \text{ N Total} = \frac{(\text{ml HCl} - \text{ml blanko}) \text{ x N HCl x } 14.008}{\text{gr sample x } 1000} \text{ x} 100\% \quad (6)$$

Protein content (%) = N (%) x conversion factor (7)

Conversion factor = 6.25

e. Carbohydrate Content (The Carbohydrate by Difference Method (Winarno, 2008))

The determination of carbohydrates using the by difference method is calculated through 100% deducting % water content, % ash content, % protein content, and % fat content. The formula for calculating carbohydrate levels is:

Carbohydrate content = 100% - (% protein content + % fat content + % ash content + % moisture content) (8)

f. Total Fiber Content (The Definition of Dietary Fiber, Association of Official Analytical of Chemist, 2005)

Extraction of food fiber was carried out by preparing 2 grams of sausage samples and dissolving them in 20 ml of distilled water. The pH was adjusted to 1.5 by adding a 4 M HCl solution. The solution was added with 0.3 grams of pepsin enzyme and incubated with agitation at 40 °C for 1 hour. The incubated solution was diluted with the addition of 20 ml of distilled water. The solution is adjusted to pH 8 with 0.3 grams of pancreatin then adjusted to pH 4.5 by adding 4 M HCl. Suspension samples were filtered to separate the filtrate and residue using pre-weighed filter paper.

The residue from the first filter was rinsed using 2 x 10 ml distilled water, 95% ethanol 2 x 10 ml. The residue from the filtering is put into an oven at 100 °C for 24 hours. The dried residue is then cooled in a desiccator for 15 minutes and weighed, expressed as insoluble dietary fiber (IDF).

The first filtrate was diluted with 100 ml of distilled water and 280 ml of 95% ethanol at 60 °C. The solution was precipitated for 1 hour and filtered. The second residue was washed with 2 x 10 ml distilled water, 2 x 10 ml 95% ethanol, and 2 x 10 ml acetone. The residue is then put in the oven for 24 hours. After the residue is dry, it is put into a desiccator for 15 minutes. The yield of the oven and the desiccator was weighed and expressed as soluble dietary fiber (SDF). Total dietary fiber (TDF) is obtained by adding IDF and SDF. The method of calculating the IDF and SDF weights is as follows:

SDF (%) = (c - b) / a x 100% (9)

IDF (%) = (e - d) / a x 100% (10)

TDF (%) = SDF + IDF (11)

where,

a = initial sample weight

b = initial filter paper weight

c = filter paper and sample weight after oven process

d = beaker glass weight

e = beaker glass and sample weight after oven process

3. Organoleptic Test

The organoleptic test parameters used are color, aroma, texture, taste, and overall. The organoleptic test used 25 semi-trained panelists (Unimus, 2013). The organoleptic test was carried out by placing the sample in a uniform container coded and presented to the panelists. Panelists were asked to give preference for each parameter in the sample presented according to a predetermined value. The panelists then made observations on color, aroma, taste, texture, and the overall preference with the organoleptic scale used as follows:

1. = very dislike
2. = don't like it
3. = somewhat don't like it
4. = just ordinary
5. = somewhat like it
6. = like
7. = really like it

Analysis of Chemical, Physical and Organoleptic Properties Test Data

The analysis was carried out using analysis of variance (ANOVA) with a significance level of 95%. If there was a significant effect between treatments, it was continued with the Duncan Multiple Range Test (DMRT) difference tests using Statistical Product and Service Solutions (SPSS) 25. Organoleptic tests were analyzed using the Chi-squared test, with a significance level of 95% using Microsoft Excel 2010. Furthermore, determining the best treatment of all treatments using the de Garmo method (De Garmo, Sullivan, & Cerook., 1997).

RESULTS AND DISCUSSION

Physical Characteristics of Sausages

Sausage Color Brightness

Color is an essential parameter of food product quality besides taste, nutritional value, and other parameters (Ismawati & Putri, 2018). The color of food products is often used as one of the parameters for the physical and chemical quality of the product (Zulfa, Kumalaningsih, & Effendi, 2014). Based on Table 1, analog meat substitution shows a significantly different effect on sausage color. The highest value of sausage color brightness was in treatment P1, while the lowest color brightness value was in treatment P5.

The sausage color brightness results show that the sausage color get darker if the ratio of analog meat used in sausage production is high. Also, the higher the carbohydrate content in the sausage, the lower the brightness of the color (tends to be dark). This is because the Maillard reaction occurs between the aldehyde groups of reducing sugars and the amine groups of amino acids, especially epsilon-amino-lysine and alpha-amino N-terminal amino acids. High temperatures cause this reaction during steaming (Nugrahedi et al., 2016).

Sausage Texture

Observation of sausage texture was carried out using the Rheotex instrument. The greater the rheological properties, the tougher the sausage texture. Based on Table 1, analog meat substitution shows a significantly different effect on sausage texture. The highest textural hardness value in sausages was treatment P5, while the lowest texture hardness value was treatment P1.

Sausage texture tends to be soft with a higher ratio of chicken meat used. This is because the fat content in chicken meat can maintain the stability of the emulsion. The resulting sausage becomes more elastic and soft (Adiaprana, Ma'ruf, & Anggo, 2016). Conversely, the greater the addition of analog meat, the tougher texture of the sausage. This happens because analog meat increases the dough volume. Thus, the water holding capacity will increase and reduce shrinkage. The starch content in analog meat forms a gel through the gelatinization process, causing the sausage texture more compact (Schirmer, Jekle, & Becker, 2015).

Scanning Electron Micrograph (SEM)

One of the parameters of chicken sausage with analog meat substitution is the formation of the texture structure and fibers of the product. In this study, SEM analysis was used to determine the cohesiveness of the texture and the fibers formed. SEM analysis was also carried out on commercial sausages on the market. The results of SEM analysis can be shown in Figure 1.

Based on Figure 1, SEM observations show that the more fiber in the sausage, the higher the analog meat composition. The more use of analog meat, the higher the protein content. Protein networks form compact fibers so that the surface structure of the sausage is more compact. A study by Samard & Ryu (2019), showed that the SEM photo observation of analog meat showed a fiber that was a network protein. In this study, extrusion was carried out at temperatures above 130 °C so that the fibers formed were more compact. The research results on analog meat substitution chicken sausage showed that, even without extrusion, protein networks were still formed due to the influence of shear forces.

The less the ratio of chicken meat used, the less fiber formed due to the low protein network. According to Lin et al. (2017), in analog meat production, the formation of protein networks occurs due to the addition of 10% SPI. This is also supported by Hu et al. (2013), the protein network was formed due to the addition of 30% SPI. This can result in the structure of the protein matrix-forming aggregates such as fibers due to protein cross-links and interactions between proteins and other components.

Chemical Characteristics of Sausages

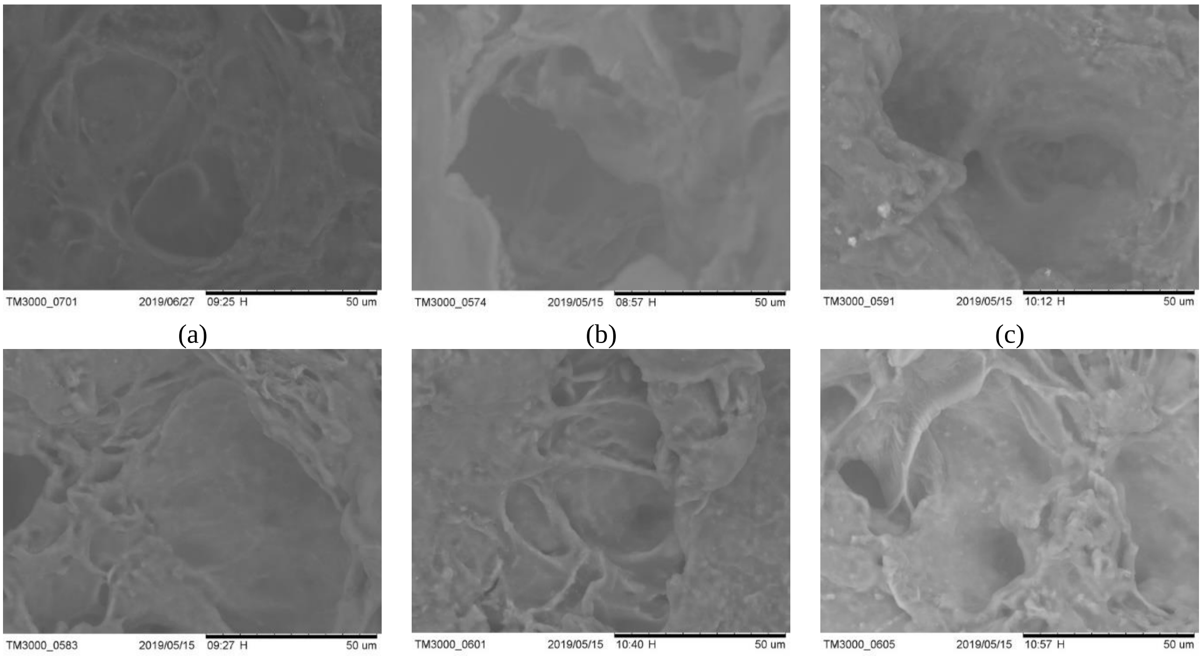
Water Content

Water is an essential component of food products. The water content in a food product can affect the appearance, texture, taste, and shelf life of the food product (Zhang et al., 2018). Based on Table 1, analog meat substitution shows a significantly different effect on sausage moisture content. The water content of P2 and P3 treatments did not show a significant difference. The highest moisture content of sausage was in treatment P1, while the lowest was in treatment P5. This is because the variations in the chicken meat used are

Table 1. Physical and chemical characteristics of chicken sausage with analog meat substitution

Characteristics of Chicken Sausage	Treatment				
	P1	P2	P3	P4	P5
Color brightness (L)	57.06^{e}	54.81^{d}	52.66^{c}	51.03^{b}	47.58^{e}
Water content (%)	52.17^{d}	51.21^{c}	51.01^{c}	50.51^{b}	50.06^{a}
Ash content (%)	0.93^{a}	1.02^{b}	1.13^{c}	1.24^{d}	1.35^{e}
Fat content (%)	22.9^{e}	20.88^{d}	19.2^{c}	18.25^{b}	17.38^{a}
Protein content (%)	19.08^{a}	20.15^{b}	21.13^{c}	22.1^{d}	23.14^{e}
Carbohidrate content (%)	4.92^{a}	6.74^{b}	7.54^{c}	7.9^{c}	8.06^{d}
Total Fiber content (%)	0.17^{a}	0.35^{b}	0.53^{c}	0.68^{d}	0.86^{e}

Different letters shows significantly different results on $\alpha = 0.05$



(a) Control Sausage (Commercial); (b) P1; (c) P2; (d) P3; (e) P4; (f) P5
Figure 1. The Scanning Electron Micrograph (SEM) Test Results

affected the moisture content of the sausages. Analog meat as a filler for sausage undergoes gelatinization and causes an increase in the volume of the dough (Rauf & Sarbini, 2015). Treatment P1 to P5 has a value range of 50.6% - 52.17%. Thus, all treatments still meet SNI 3820-2015, which is less than 67%.

Ash Content

Based on Table 1, analog meat substitution shows a significantly different effect on the content of shredded sausage. The highest ash content was in the P5 treatment sausage, while the lowest was in the P1 treatment sausage. The ash content of the sausages is influenced by each ingredient's content (Palandeng, Mandey, & Lumoindong, 2016). Based on the composition of the raw materials used, the higher the addition of analog meat, can increase the ash content of the sausages. The average sausage ash content with various treatments has a value range of 0.93% -1.35% or below 3% according to the maximum standard of SNI 3820-2015.

Fat Content

Based on Table 1, analog meat substitution shows a significantly different effect on sausage fat content. The highest fat content was in treatment P1, while the lowest fat content was in treatment P5. The fat content in sausages is much influenced by chicken meat because the average fat content of analog meat raw materials is lower than the fat content of chicken meat. The average fat content of sausages with various treatments has a value range of 17.38% - 22.90%. This value still meets SNI 3820-2015, which is less than 25%.

Protein Content

Based on Table 1, analog meat substitution shows a significantly different effect on sausage protein content. The highest protein content was in treatment P5, while the lowest protein content was in treatment P1. Thus, the higher the use of analog meat in sausage production, the higher the protein content (Prastini & Widjanarko, 2015). The average protein content of sausage with various treatments has a value range of 19.08% -23.14%. So, it still meets SNI 3820-2015, which is more than 13%.

Carbohydrates Content

Based on Table 1, analog meat substitution shows a significantly different effect on sausage carbohydrates content. The levels of carbohydrate treatment P3 and P4 did not show a significant difference. The highest carbohydrate content was in the P5 treatment, while the lowest carbohydrate content was in the P1 treatment. The carbohydrate content of sausages is calculated using the by difference method (Winarno, 2008) by calculating the number 100% minus the percentage (%) of water content, ash content, fat content, and sausage protein content. Thus, increasing the moisture content, ash content, fat content, and protein content of the sausage causes the carbohydrate content to decrease. If the moisture, ash, fat, and protein content of sausages decrease, the carbohydrate content will increase (Estiningtyas and Rustanti, 2014). The average carbohydrate content of sausages with various treatments has a value range of 4.92% -8.06%. The SNI 3820-2015 states that the standard carbohydrate content is less than 8%. Thus, the carbohydrate content of sausages with P5 treatment of 8.06% did not meet these standards. On the other hand, treatment P1 to P4 still meets SNI 3820-2015 standard.

Total Fiber Content

Fiber content is a type of non-starch polysaccharide that cannot be digested by human digestive enzymes (Astuti, 2012). The results of measuring the total fiber content of sausages can be seen in Table 1. The highest total fiber was found in treatment P5, while the lowest fiber content was in treatment P1. The total fiber content of sausages is also influenced by the total fiber content of each raw material. The total fiber content of *gembili* flour was 2.33% (Herlina et al., 2015), and *Anjasmoro* soybean flour was 3.06%. This shows that increasing the amount of analog meat will increase the total fiber content of the sausage.

Organoleptic Characteristics of Sausage

Color Preference Level

Color is an essential attribute in a food product because it appeals before consumers eat or buy the food product (Spence, 2015). Table 2 shows that the ratio between chicken meat and analog meat significantly affects the sausage color preference level by the panelists. The high carbohydrate content in sausages using more analog meat than chicken meat causes a Maillard reaction when steaming the sausages (Teodorowicz, van Neerven, & Savelkoul, 2017). The Maillard reaction occurs between the aldehyde groups producing sugar with the amine groups of amino acids, especially epsilon-amino-lysine and alpha-amino N-terminal amino acids (Hermayanti, Rahmah, & Wijana, 2016). This can be seen in the color brightness test with a color reader. The lower the color value (tends to be dark), the sausage carbohydrate content is higher. The higher the color value (tends to be bright), the sausage carbohydrate content is lower. The P3 treatment has a color brightness value of 52.66, and treatment P5 has a color brightness value of 47.58. So, it can be seen that P5 has a darker color than the P3 treatment, which tends to be pale. This is because chicken meat contains the protein pigment oxymyoglobin (bright red), which can turn into metmyoglobin (brown) due to protein denaturation factors (Farida, Rahmat, & Amanda, 2018). P3 treatment has the highest panelist color preference with 85%, while the lowest is P5 treatment with 32%.

Aroma Preference Level

The aroma is defined as a stimulus produced by a food ingredient easily recognized by the sense of smell. The aroma can influence consumer judgment, even before consuming foods (Ployon, Morzel, & Canon, 2017). The Chi-squared test results in Table 2 show that the ratio between chicken meat and analog meat is not significantly different from the panelists' aroma preference. Overall, the aroma in the sausages tends to be like the aroma of soybeans because the ingredients used are SPI and *Anjasmoro* soybean flour. The panelists could not distinguish the sausage aroma in all treatments.

Texture Preference Level

Sausage texture is influenced by analog meat as a filler. When the protein of chicken meat experiences shrinkage due to the denaturation

Table 2. Organoleptic characteristics of chicken sausage with analog meat substitution

Sausage Characteristics	Statistical Chi-squared	Table Chi-squared
Color preference level	59.11	36.42
Aroma preference level	24.56	36.42
Texture preference level	53.65	36.42
Taste preference level	56.65	36.42
Overall preference level	42.83	36.42

process, it will be filled with gelatinized analog meat starch molecules to compact the texture (Sundari, Almasyhuri, & Lamid, 2015). The high ratio of using analog meat causes the sausage texture to get tougher. The lower the analog meat added, the softer the sausage texture. The Chi-squared test results showed that the difference in the ratio between chicken meat and analog meat was significantly different from the panelists' level of preference for sausage texture.

Taste Preference Level

The use of analog meat raw materials made from gluten, SPI, and *Anjasmoro* soybean flour in treatment P5 reduced the level of taste preference in sausages. This reduced level of taste preference is because legume products, especially soybeans, have an off-flavor compound (an unpleasant taste) (Rahayu, Asih, & Arsil, 2018). The seasoning used in sausage production can also affect the level of taste preference (Spence and Velasco, 2018). Besides raw materials and seasonings, the level of taste preference is also influenced by the texture and aroma preference. Because when consumed, the texture is felt when chewed and at the same time can smell the aroma of sausage (Ployon et al., 2017). The Chi-squared test results in the table show that the difference in the ratio between chicken meat and analog meat is significantly different from the panelists' level of sausage taste preference.

Overall Preference

The overall parameter is the panelist's assessment of all sensory attributes: the color, aroma, texture, and taste of sausage. The Chi-squared test results in the table show that the difference ratio between chicken meat and analog meat is significantly different from the overall preference of sausage by the panelists.

Determination of Best Treatment

The best treatment selection used the effective index method on the sausages' physical, organoleptic, and chemical parameters. The weighted panelist data then calculated using the effective index method or the de Garmo method. The best formula obtained is the sausage formula with 30% analog meat (P3). In this treatment, the sausage has physical properties color brightness level (L) 52.66, water content 51.01%, ash content 1.13%, fat content 19.2%, protein content 21.13%, carbohydrate content 7, 54%, the total fiber content is 0.53%.

CONCLUSION

The results showed that the substitution of chicken meat with analog meat had a significant effect on the physical and chemical properties of chicken sausage. The measurement of the physical properties of the color brightness shows that the higher the ratio of analog meat in sausages production, the darker it is. The texture of the sausages tends to be tougher the higher the use of analog meat is. The measurement of chemical properties showed that the analog meat substitution increased protein content, ash content, and total fiber content but decreased water content and sausage fat content. Analog meat substitution has a significant effect based on an analysis of the level of preference for color, texture, taste, and overall. On the other hand, analog meat substitutes were not significantly different in the level of color preference. The best analog meat substitution treatment in sausage production was based on panelists' assessment regarding physicochemical and sensory properties is P3 treatment (70% chicken meat : 30% analog meat).

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