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The Effect of Proportions of Koro Beans (*Canavalia ensiformis*) and Carrot (*Daucus carota*) with Soy Protein Isolate Addition on the Characteristics of Analog Sausage

Aidha Safa Asy'ari[1], Rosida[2].
[1] *Food Technology Department, Faculty of Engineering and Science, National Development University "Veteran" East Java, Surabaya, Indonesia*

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CORRESPONDING AUTHOR

*E-mail: rosidaupnjatim@gmail.com

A B S T R A C T

Analog sausage is a sausage made from plant-based food ingredients. Koro beans can be used as the main ingredient because they are high in protein and low in fat. We use carrots as coloring because they contain carotenoid compounds. We added soy protein isolate (SPI) to boost the product's protein content and enhance its texture. This study aimed to determine the effect of the proportion of koro beans and carrots, with the addition of soy protein isolate, on the characteristics of analog sausage. This research used a completely randomized design (CRD) factorial pattern with two factors. Factor I is the proportion of koro beans to carrots (80:20; 70:30; 60:40), and Factor II is the addition of soy protein isolate (5%; 10%; 15%). We analyzed the data using ANOVA and DMRT tests at the 5% level. The best combination was using koro beans and carrots in an 80:20 ratio along with 15% soy protein isolate, which created an analog sausage with 57.52% moisture, 1.38% ash, 27.76% protein, 4.11% fat, 88.44% water-holding capacity, 3027.15 g hardness, and 927.95 g chewiness, plus taste tests showed a color score of 3.08, aroma of 3.28, taste of 2.72, and texture of 3.2.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-Being
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action

1. INTRODUCTION

1.1. Research Background

Sausage is a popular product because it is affordable, fast food that is easy to process, practical and durable, and has a good taste [1]. However, meat-based sausages are not good if consumed excessively because they contain a lot of saturated fat, which can accumulate cholesterol and cause various diseases. Therefore, it is necessary to develop sausages with alternative non-animal raw materials such as analog sausages to have good nutritional content [2].

Analog sausages are sausages made from plant-based food ingredients. One of the food sources that can be utilized in sausage production is koro beans. Koro beans can be used as an alternative to meat because they contain a high level of protein (28.6%) and a low fat content (2.26%) [3]. However, the public does not widely use koro beans because they have the disadvantage of containing cyanide acid (HCN), which can be harmful if consumed in excess. Howevwe, the right processing methods, such as washing, soaking, and heating can reduce the HCN levels[4].

The use of carrots is necessary in producing analog sausages to improve the quality of appearance and nutrition. Carrots contain beta-carotene pigments that can provide orange color and flavonoids that act as antioxidants. In addition, it contains several types of important nutrients, such as vitamin C, vitamin E, calcium, and phosphorus[5].

Sausage production often has an issue with the instability of the dough emulsion system so that the texture is not compact, too hard, or too soft. One way to address this problem is by adding an emulsifier such as soy protein isolate (SPI). Adding SPI can increase protein content and improve the product's texture. SPI is a binder in the mixture because it enhances emulsion properties during sausage production, acts as a gelling agent, enhances flavor, and provides a chewy texture [6].

1.2. Literature Review

Analog sausages are made from non-meat-based ingredients, commonly called vegetarian sausages. Analog sausages have advantages compared to sausages in general, including protein and fiber content, which are beneficial for the health of the body [7].

Koro beans contain a relatively high protein content of 28.6%, making them a potential vegetable protein source [8]. However, its utilization is still lacking because it contains cyanide acid (HCN), which is toxic to the body. However, the content can be reduced by washing, soaking, and fermentation to become safe for consumption [9].

Adding carrots can produce sausages with bright colors due to beta-carotene pigments, which makes the sausages brighter orange. Carrots have a beta-carotene content of 8285 µg/100g [10]. Carrots also contain folic acid compounds, pantothenic acid, and other essential elements K, Na, Ca, Mg, P, S, Mn, Fe, Cu, and Zn [11].

Soy Protein Isolate (SPI) is a product derived from low-fat soy flour with a minimum protein content of 90% on a dry basis [12]. SPI can be added to food products to improve physical characteristics and increase nutritional value, especially protein [13]. SPI has a high level of polarity, which allows the protein-water phase to form a stronger matrix and more fat granules can be enveloped to make the emulsion more stable [14].

1.3. Research Goals

This study aims to analyze the effect of koro beans and carrot proportions with the soy protein isolate addition on analog sausage characteristics and determine the best treatment combination from these variations.

2. MATERIALS AND METHODS

2.1. Material

The materials used for this study are koro beans, carrots, soy protein isolate, tapioca flour, salt, oil, sugar, ground pepper, ground nutmeg, mushroom stock, shallots, and garlic. The materials for analysis include aquades, n-hexane, sulfuric acid, Kjeldahl tablets, sodium hydroxide, methyl red indicator, bromocresol green indicator, 95% alcohol, boric acid, hydrochloric acid, acetone, sodium sulfate, and petroleum ether.

2.2. Research Procedures

This research was conducted experimentally using a completely randomized design (CRD) factorial pattern consisting of 2 factors: Factor I, the proportion of koro beans: carrot (80:20; 70:30; 60:40), and Factor II, the addition of soy protein isolate (5%; 10%; 15%). ANOVA analyzed the data obtained to determine the effect of treatment with 2 replications. If there is a significant difference, further testing is carried out using the DMRT (Duncan Multiple Range Test) method at a level of 5%.

2.3. Making Koro Beans Paste

Koro beans are sorted to get the good ones. After sorting, koro beans were soaked in water for 72 hours in a ratio of (1:3). The soaking water of koro beans was replaced every 6 hours. After that, the koro beans were drained, peeled to remove their seed coats, and then boiled for 10 minutes. Next, the koro beans were blended with water and koro beans of 1:2.5 ratio until white koro bean paste was obtained.

2.4. Making Carrot Paste

Fresh carrots were peeled and washed to remove any dirt. Then, carrots were cut and steamed (blanching) at 75°C for 5 minutes. After that, the carrots are blended for ± 5 minutes until smooth and form a paste.

2.5. Making Analog Sausage

Mix koro beans: carrot paste (80:20; 70:30; 60:40). Add other ingredients in a blender, such as salt, oil, sugar, ground pepper, ground nutmeg, mushroom stock, shallots, and garlic. Then, tapioca flour and soy protein isolate (5%, 10%, 15%) were added to the dough. The dough was stirred continuously until homogeneous. After mixing well, the dough was put into a collagen casing, and both ends were tied. The sausages are then steamed at a temperature of 75–80°C for 45 minutes until fully cooked, ensuring that the casing remains intact and does not rupture.

3. RESULT AND DISCUSSION

3.1. Physicochemical Characteristics of Analog Sausage

Table 1. Analysis result of water, ash, fat, and protein content.

Treatment	Moisture (%)	Ash (%)	Fat (%)	Protein (%)
A1B1	60.17	1.26	5.11	24.79
A1B2	59.87	1.31	4.44	25.37
A1B3	57.52	1.38	4.11	27.76
A2B1	62.10	1.22	4.22	23.06
A2B2	60.99	1.30	3.88	24.33
A2B3	59.63	1.35	3.45	25.78
A3B1	63.91	1.21	3.35	20.40
A3B2	61.55	1.22	2.90	23.26
A3B3	59.91	1.26	2.68	24.51

Water content showed that the lower proportion of koro bean paste and the higher carrot paste caused the moisture content of analog sausages to increase. Still, the higher addition of soy protein isolate caused the moisture content to decrease. This is caused by the water content of carrot (88,36%) being higher than koro beans paste (76,96%), while SPI has a low moisture content of only 5.91% so that the addition of SPI causes the moisture content to decrease [15]. Moreover, carrots contain fiber content 2.8 g/100 g. Hydroxyl groups in carrot fibers play a role in forming hydrogen bonds with water molecules so that water can be trapped in the fiber matrix which can cause the water content to decrease [16]. The decrease in moisture content also influenced by the addition of SPI due to the increasing amount of solids.

Ash content showed that the lower proportion of koro bean paste and the higher carrot paste cause the ash content of analog sausages to decrease, but the higher addition of soy protein isolate caused the ash content of analog sausages to increase. Ash content reduces due to the mineral content of the raw materials used, which koro beans contain higher ash content (1.04%) than carrot paste (0.98%). Meanwhile, the addition of SPI causes an increase in ash content because SPI contains 5.2% ash content [17].

Fat content showed a lower proportion of koro bean paste and a higher carrot paste, and the more isolate soy isolate added caused the fat content of analog sausages to decrease. Fat content decreases because koro beans contain higher fat content than carrot paste. SPI also has low fat content so which causes the fat content to decrease. Fat content in SPI is only 0,06% [18].

Protein content showed that the higher carrot paste proportions cause the protein content of analog sausages to decrease, but the higher addition of soy protein isolate causes the protein content to increase. This is caused by the protein content of koro bean (20,67%) is higher than carrot paste (0,93%), while SPI has high protein content so that the addition of SPI causes the protein content to decrease [19]. SPI is a pure soy protein with a protein content of at least 90%, so its addition to analog sausages greatly affects the protein content [20].

Table 2. Analysis results of water holding capacity (WHC), hardness, and chewiness.

Treatment	WHC (%)	Hardness (g)
A1B1	78.70	2019.68
A1B2	83.90	2448.14
A1B3	88.44	3027.15
A2B1	75.44	1226.13
A2B2	82.08	1853.57
A2B3	85.42	2548.58
A3B1	71.65	1018.71
A3B2	76.82	1624.25
A3B3	82.86	2371.63

Water holding capacity (WHC) showed that higher carrot paste proportions cause the protein content of analog sausages to decrease, but the higher the addition of isolate soy protein increases WHC. This is caused by the protein's ability to bind water. Proteins are compounds that have hydrophilic groups that can bind water. Water binding occurs between hydrophilic protein groups that interact with water molecules through bonds. Therefore, adding SPI can also affect WHC levels by increasing protein [21]. The amount of protein added will impact the amount of water bound in the protein matrix or emulsion matrix, characterized by an increase in the water holding capacity (WHC) value [22].

Hardness showed that the higher carrot paste proportions caused the hardness of analog sausages to decrease, but the higher the addition of isolate soy protein, the higher the hardness. The moisture content of the material causes this. Carrot paste has a higher moisture content than koro bean paste. High water content causes hardness to decrease, making the texture softer [23]. Hardness values can also be caused by increased protein content due to the addition of SPI. The added SPI causes the texture to become more compact because SPI will increase the number of cross-links between proteins that form a three-dimensional structure [15].

3.2. Physicochemical Characteristics of Analog Sausage

Table 3. Organoleptic test result of analog sausage.

Treatment	Color (%)	Aroma (%)	Taste (%)	Texture (%)
A1B1	3.44	3.12	3.76	2.28
A1B2	3.2	3.36	3.04	2.68
A1B3	3.08	3.28	2.72	3.2
A2B1	3.64	3.04	3.88	2.32
A2B2	3.24	2.96	3.36	2.8
A2B3	3.36	3.2	3.2	3.52
A3B1	4.16	3.24	4	2.92
A3B2	3.92	3.28	3.6	3.4
A3B3	3.68	3.44	3.52	3.92

The results of an organoleptic test of the color of the analog sausage showed a significant difference ($p \leq 0.05$). It can be seen that the panelists' preference level for the color of the analog sausage obtained the highest rating with an average of 4.16, which was found on the proportion of koro beans and carrot paste (60:40) with the addition of 5% soy protein isolate. In contrast, the lowest rating, with an average value of 3.08, was found in the proportion of koro beans and carrot paste (80:20) with the addition of 15% soy protein isolate. The analysis showed that panelists liked the color of analog sausage with a high proportion of carrot paste. Analog sausage produces orange due to the beta-carotene content, a natural pigment in carrots [25]. However, the addition of SPI decreases the panelists' liking value. This is because SPI can cause the color of the product to become darker [26].

The results of an organoleptic test of the aroma of the analog sausage showed no significant difference ($p \geq 0.05$). It can be seen that the panelists' preference level for the aroma of the analog sausage obtained the highest rating with an average of 3,44, which was found on the proportion of koro beans and carrot paste (60:40) with the addition of 15% soy protein isolate. In contrast, the lowest rating, with an average value of 2,96, was found in the proportion of koro beans and carrot paste (70:30) with the addition of 10% soy protein isolate. There is no significant difference in the aroma of analog sausage because aroma of koro bean, carrot, and SPI does not have a strong or unique odor [27] [28].

The results of an organoleptic test of the taste of the analog sausage showed a significant difference ($p \leq 0.05$). It can be seen that the panelists' preference level for the flavor of the analog sausage obtained the highest rating with an average of 4, which was found on the proportion of koro beans and carrot paste (60:40) with the addition of 5% soy protein isolate. In contrast, the lowest rating, with an average value of 2.72, was found in the proportion of koro beans and carrot paste (80:20) with the addition of 15% soy protein isolate. The analysis showed that panelists liked the taste of analog sausage with a high proportion of carrot paste because the natural sweetness inside carrots can enhance the product's flavor. The high addition of SPI causes the taste of analog sausage to be nutty and slightly bitter due to soy saponin and sapogenol compounds, which are glycosides found in soybeans [26].

The results of an organoleptic test of the texture of the analog sausage showed a significant difference ($p \leq 0.05$). It can be seen that the panelists' preference level for the texture of the analog

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sausage obtained the highest rating with an average 3,92, which was found on the proportion of koro beans and carrot paste (60:40) with the addition of 15% soy protein isolate. In contrast, the lowest rating, with an average value of 2.28, was found in the proportion of koro beans and carrot paste (80:20) with the addition of 5% soy protein isolate. The analysis showed that panelists liked the taste with a high proportion of carrot paste because it makes the texture of analog sausage softer. Moreover, panelists like high SPI because it can make sausage analog compact and solid [29].

4. CONCLUSION

The proportions of koro beans and carrots with the addition of soy protein isolate on analog sausage significantly affected water content, protein content, WHC, hardness, and chewiness. They influence on colour, taste, and texture scores of analog sausage. However, it did not significantly affect analog sausage's ash content, fat content, and aroma scores. The best treatment was the proportion of koro beans: carrot (80:20) and the addition of 15% soy protein isolate which produced analog sausage with 57.52% moisture content, ash content 1.38%, protein content 27.76%, fat content 4.11%, WHC 88.44%, hardness 3027.15 g, and chewiness 927.95 g, as well as organoleptic parameters with a color score of 3.08, aroma 3.28, taste 2.72, and texture 3.2.

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