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Effect of use of chia seed flour (*Salvia hispanica* L.) and carrot flour (*Daucus carota* L.) at different levels on physico-chemical and organoleptic qualities of chicken sausages

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ABSTRACT

The objective of this research was to evaluate the physical, chemical, and organoleptic qualities of chicken sausages with chia seed flour and carrot flour fillers with different substitution levels. The study design used a completely randomized design with 5 treatments and 5 replications and the treatments included 0% chia seed flour and 0% carrot flour (L0), 3% chia seed flour and 0.75% carrot flour (L1), 6% chia seed flour and 1.5% carrot flour (L2), 9% chia seed flour and 2.25% carrot flour (L3), and 12% chia seed flour and 3% carrot flour (L4). The research data were analysed using analysis of variance and if there was a significant effect, it was analysed further using Duncan's Multiple Range Test. The findings showed that chicken sausages with filler substitution of chia seed flour at 12% and carrot flour up to 3% had a very significant effect ($P<0.01$) on water, protein, fat, and collagen content. The content of protein, fat, and collagen of chicken sausages increased with the use of 9% chia seed flour and 1.5% (L2) carrot flour compared to the control group. The L2 treatment produced the same physical and organoleptic quality compared to the control. The results of the study concluded that the use of 6% chia seed flour and 1.5% carrot flour can improve chemical quality while maintaining physical and organoleptic quality so that it can be applied to making chicken sausages.

Introduction

Broiler chicken meat is a food that has high nutritional value, has a delicious taste and aroma, a soft texture and a relatively cheap price, and therefore many people choose to consume chicken meat compared to beef or goat (Marangoni *et al*., 2015). Chicken falls into the white meat category and is popular because of its low fat qualities. It contains 68.37% water, 21.96% protein, 3.47% fat, 2.52% carbohydrates and 0.74% ash (Liur, 2020). Fresh chicken meat also has disadvantages, namely that it is easily damaged and spoiled by microorganisms, particularly bacteria (Zhu *et al*., 2022) and therefore, processing chicken meat into a product can prevent damage and extend the shelf life. Broiler chicken meat can be processed into various processed food products, one of which is sausages.

Broiler chicken meat processing aims to extend shelf life and add value. Sausages are a practical fast-food item that is widely enjoyed by all groups. Sausages are processed meat products that are an important component of food structures, offering affordable prices and high quality (Strashynskyi *et al*., 2016). Sausages are made from a mixture of meat with salt, spices, and other ingredients, which are placed into casings of various shapes and sizes. Over time, consumer preference for sausage additives, such as animal fats with high saturated fat content, has been replaced by fillers as a plant-based fat replacer to produce healthier, better-quality sausages (Ayandipe *et al*., 2020). Filler is an important component in making sausages which can determine the quality of the sausage.

The use of filler in sausage making can increase emulsion stability, product characteristics, water holding capacity, texture, taste, freeze-thaw stability through modified starches, add bulk, and reduce formulation costs (Sembor *et al*., 2023 and Surfiana *et al*. 2024). The flour commonly used in making processed meat products including sausages is tapioca flour because it can be obtained easily and is affordable (Arnida, 2015). The addition of fillers and binders is based on their gelatinization properties in sausages which result in a firm and dense dough when mixing (Astriani *et al*., 2013). Chia seed flour can be an alternative filler added in sausages because it has gel physical properties that come from the mucilage content in chia seed flour. Chia seed contains high levels of fiber, protein, and polyunsaturated fatty acids. The chemical content of chia seed consists of 30-33% fat, 26-41% carbohydrates, 18-30% fiber, 15-25% protein, and 4-5% ash content (Tiwari and Shankar, 2023). Chia seeds also have a relatively high omega-3 fatty acid content which is beneficial for health, namely 17.83% (Rosyalia *et al*., 2024). The use of chia seed flour in processing animal meat products in the form of frankfurter sausages by Pintado *et al*. (2016) increased amounts of protein, minerals, fiber, and especially high levels of MUFA and omega-3 PUFA, especially linolenic acid. In addition, the substitution of chia seed flour filler (5-15%) in chicken sausages had a significant impact on the content of fat, ash, carbohydrate, and fiber; however, had no significant impact on the content of protein and water (Arifin *et al*., 2021).

Another ingredient that can be used as an alternative filler in making sausages is carrot flour. Carrots possess phytochemicals like phenolic compounds, carotenoids, polyacetylenes, and ascorbic acid, along with a unique flavor attributed to polyacetylenes and terpenoids, rendering them both palatable and nutritious (Sam *et al*., 2011). The chemical content of 100 g of carrots is 90.4% water content, 0.6% ash content, 0.6% protein, 0.1% fat, 1.8% fiber, and 8.2% carbohydrates (Pertiwi, 2013). Carrots can be processed into carrot flour which contains antioxidants and provitamin A. Due to their bioactive properties, carrots may serve as a superior alternative to synthetic antioxidants in fatty meat products, such as frankfurter-type sausages, which are prone to lipid oxidation (Sam *et al*., 2011). The β-carotene content in carrots can act as a natural coloring in sausage products. Numerous studies have been undertaken to examine the incorporation of carrot in the formulation of meat products, serving various roles such as a functional element (Alvarado-Ramírez *et al*., 2018), an extender (Zargar *et al*., 2017), a source of dietary fiber (Yadav *et al*.,

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2018), or a fat replacer (Öztürk-Kerimoglu *et al*., 2021). Despite numerous research documenting the incorporation of carrots (in powder, paste, or juice forms) into meat product formulations (Badr and Mahmoud, 2011; Reddy *et al*., 2018; Sam *et al*., 2011), there is a paucity of data about the application of carrot flour in the development of chicken sausage. Therefore, innovation is needed in the use of carrot flour combined with chia seed flour as a filler for chicken sausages. The resulting sausage product is expected to offer several advantages, both in terms of physicochemical quality and health benefits. Therefore, a study was needed to examine the effect of substitution of chia seed flour and carrot flour at different levels on the physical, chemical, and organoleptic quality of broiler chicken sausages.

Materials and methods

Materials

This study was carried out at the Animal Product Technology Laboratory, Faculty of Animal Science, Universitas Sebelas Maret, Surakarta and physical quality tests at the Meat Science and Technology Laboratory, Faculty of Animal Science, Gajah Mada University, Yogyakarta. The materials used in this study include ground broiler chicken breast fillet and food grade ingredients obtained commercially such as tapioca flour, chia seed flour, carrot flour, skimmed milk powder, coriander, garlic, white pepper, broth. chicken, salt and ice cubes.

Study design

The design used in this research was a unidirectional Completely Randomized Design. The sausages studied used chicken meat with chia seed flour and carrot flour in five treatments, with each treatment was repeated 5 times. The treatments used are as follows:
L0= Chicken sausage composition of 15% tapioca flour, 0% chia seeds flour, and 0% carrot flour
L1= Chicken sausage composition of 11.5% tapioca flour, 3% chia seed flour and 0.75% carrot flour
L2= Chicken sausage composition of 7.5% tapioca flour, 6% chia seed flour and 1.5% carrot flour
L3= Chicken sausage composition of 3.75% tapioca flour, 9% chia seed flour and 2.25% carrot flour
L4= Chicken sausage composition of 0% tapioca flour, 12% chia seed flour and 3% carrot flour

Methods

Making chicken sausages

The process started with washing fresh chicken meat with clean water. Then the chicken meat was diced into small pieces. The meat that was cut into pieces was then ground and divided into 5 treatments. Next, the meat was put into a mixer and along with ice cubes and spices (Table 1). The mixture that was thoroughly mixed was then put into the casing. After being placed in the casing, the sausage was steamed for±30 minutes at a temperature of 70-80°C in a steamer (Lenzun *et al*., 2021).

Physical quality testing

The physical quality assessment of the sausages in the study included measuring pH, water-holding capacity, tenderness, and cooking loss. To test the pH of the meatballs, the sample conservation included taking 5 g meatball samples which were ground. The ground samples were then placed in a beaker and mixed with 25 mL of distilled water. The mixture was blended for one minute and then the pH was measured using a calibrated pH meter set at 4 and 7 (AOAC, 2005). The water-holding capacity was measured with the Hamm method whereby a sample of 0.3 g was weighed and then pressed with a load of 35 kg for 5 minutes. The region containing the meatball sample and the wet surrounding area was marked and measured with a planimeter to yield a value of mgH_2O. The value of mgH_2O obtained was used to determine the free water content and water-holding capacity was obtained from the difference of total water content and free water content. Cooking loss was calculated from the difference in weight of the sausage both pre and post cooking, and expressed in percentage (Kartikasari *et al*., 2020). Quality of tenderness of the sausage was measured using a penetrometer.

Chemical quality testing

Chemical quality testing used a food scan tool (NIRs spectroscopy) which included testing water, protein, fat and collagen content (Marza *et al*., 2018) with duplo testing on each treatment sample at the Laboratory of Meat Science and Technology, Faculty of Animal Husbandry, Gadjah University Mada, Yogyakarta. The working principle of the NIRs method is based on the presence of molecular vibrations that correspond to the wavelengths listed in the near infrared region of the electromagnetic spectrum (Adrizal *et al*., 2007). The NIR technique is a fast analysis technique that does not damage the material sample to be analysed (Mechram *et al*., 2021)

Organoleptic quality testing

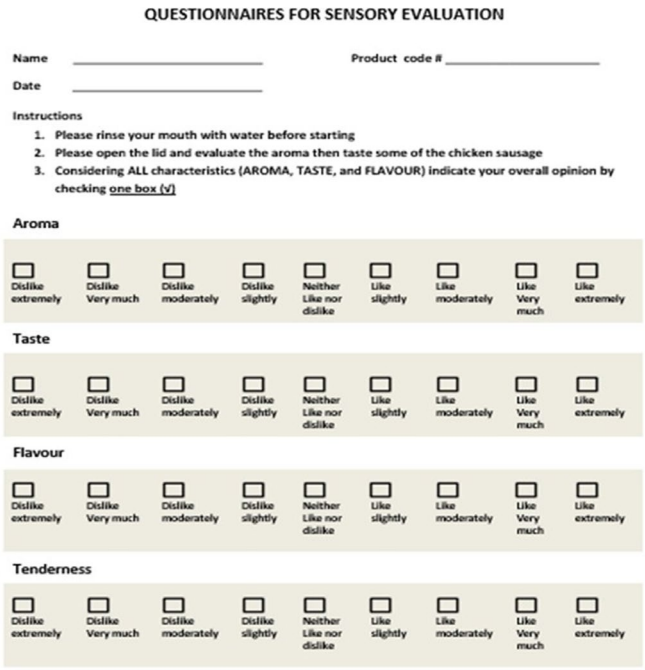
The assessment was conducted by 35 semi-trained panellists. The panellists were collected by administering a questionnaire to get information regarding the consumption of chicken sausage, including potential allergies to chicken, their level of liking, and their frequency of consumption. The sausage samples were placed in sealed containers coded with a random three-digit number and placed in a bain marie at 40°C to keep warm before serving. Prior to organoleptic testing, the panellists were explained the sausage organoleptic quality testing procedure. Consent

Table 1. Formula for making sausages (%) using chia seed flour and carrot flour as a substitute for tapioca flour.

Sausage Ingredients Components	L0	L1	L2	L3	L4
Chicken meat	63.25	63.25	63.25	63.25	63.25
Tapioca flour	15	11.25	7.5	3.75	0
Chia seed flour	0	3	6	9	12
Carrot flour	0	0.75	1.5	2.25	3
Spices	21.75	21.75	21.75	21.75	21.75
Total	100	100	100	100	100

L0 = Chicken sausage composition of 15% tapioca flour, 0% chia seed flour, and 0% carrot flour.
L1 = Chicken sausage composition of 11.25% tapioca flour, 3% chia seed flour and 0.75% carrot flour.
L2 = Chicken sausage composition of 7.5% tapioca flour, 6% chia seed flour and 1.5% carrot flour.
L3 = Chicken sausage composition of 3.75% tapioca flour, 9% chia seed flour and 2.25% carrot flour.
L4 = Chicken sausage composition of 0% tapioca flour, 12% chia seed flour and 3% carrot flour.

forms were distributed, and the panellists were asked to sign them. The panellists assessed sausage attributes using a 9-point hedonic scale (Figure 1). The scoring used in testing consumer preference levels is shown in Figure 1. The organoleptic attributes assessed included aroma, colour, texture, tenderness, juiciness, aftertaste, taste, and flavour. In order to neutralise the taste, after testing each sample, panellists were asked to drink water and eat plain crackers. The panellists provided a 1-minute rest period between each sample (Kartikasari *et al*., 2020).


QUESTIONNAIRES FOR SENSORY EVALUATION

Name _____ Product code # _____

Date _____

Instructions

1. Please rinse your mouth with water before starting
2. Please open the lid and evaluate the aroma then taste some of the chicken sausage
3. Considering ALL characteristics (AROMA, TASTE, and FLAVOUR) indicate your overall opinion by checking one box (√)

Aroma

☐ Dislike extremely ☐ Dislike Very much ☐ Dislike moderately ☐ Dislike slightly ☐ Neither Like nor dislike ☐ Like slightly ☐ Like moderately ☐ Like Very much ☐ Like extremely

Taste

☐ Dislike extremely ☐ Dislike Very much ☐ Dislike moderately ☐ Dislike slightly ☐ Neither Like nor dislike ☐ Like slightly ☐ Like moderately ☐ Like Very much ☐ Like extremely

Flavour

☐ Dislike extremely ☐ Dislike Very much ☐ Dislike moderately ☐ Dislike slightly ☐ Neither Like nor dislike ☐ Like slightly ☐ Like moderately ☐ Like Very much ☐ Like extremely

Tenderness

☐ Dislike extremely ☐ Dislike Very much ☐ Dislike moderately ☐ Dislike slightly ☐ Neither Like nor dislike ☐ Like slightly ☐ Like moderately ☐ Like Very much ☐ Like extremely

Fig. 1 Hedonic scale for sensory evaluation of chicken sausages.

Data analysis

With RStudio v2022.02.2+485, this study evaluated the impact of substituting chia seed flour and carrot flour on chicken sausage quality using ANOVA Analysis of Variance. If there was a real effect on the treatment, it was continued by carrying out Duncan's Multiple Range Test with a significant difference of $P<0.05$.

Results

Physical quality testing

The findings indicated that the substitution of tapioca flour with chia seed flour and carrot flour resulted in significant differences ($P<0.05$) in the pH value, WHC of cooked sausages, and cooking loss, but did not produce significant differences ($P>0.05$) in the WHC value of raw sausages and tenderness level (Table 2). There was a tendency for pH to decrease with increasing levels of chia seed flour and carrot flour, with treatment L4 having the lowest pH value (6.12) compared to L0 (6.18) and L1 (6.20). The use of 6-12% chia seed flour and 1.5-3% carrot flour produced the same pH value. There were no significant differences in the water holding capacity of raw sausages by increasing levels of chia seed and carrot flour. Similarly, no significant difference was observed in the water holding capacity of cooked sausages by increasing chia seed and carrot flour up to levels of 9 and 2.25%, respectively. The findings showed that there was a very significant difference ($P<0.01$) from the use of chia seed flour and carrot flour as a substitute for tapioca flour on the cooking loss value of chicken sausages. Cooking loss in sausages produced with L3 treatment was smaller compared to L0, L1, L2, and L4. There was no difference in cooking loss between treatments L0, L1, L2, and L4. The research data showed that the tenderness value of sausages in treatments L0, L1, L2, L3, and L4 had the same values.

Chemical quality

The results of chemical quality on chicken sausages with chia seeds and carrot flour addition as a substitute for tapioca flour are shown in Table 3. The use of chia seed flour and carrot flour as a substitute for tapioca

Table 2. Physical quality of chicken sausage using chia seed flour and carrot flour at different levels.

Parameters	Treatments					*P value*
	L0	L1	L2	L3	L4	
pH	6.18±0.03^{ab}	6.20±0.01^{a}	6.16±0.03^{bc}	6.15±0.01^{bc}	6.12±0.01^{c}	0.00
WHC Raw (%)	51.25±2.19	48.68±2.78	50.85±3.62	51.57±2.67	51.03±4.03	0.62
WHC Cooked (%)	38.40±3.86^{a}	38.47±4.68^{a}	35.70±2.36^{a}	35.79±3.05^{a}	23.45±3.05^{b}	0.00
Cooking Loss (%)	1.91±0.46^{a}	2.12±0.30^{a}	2.06±0.50^{a}	1.13±0.37^{b}	1.96±0.17^{a}	0.00
Tenderness (mm/g/second)	10.28±0.70	11.60±0.90	11.33±0.76	10.69±1.33	10.91±0.72	0.21

^{a,b}Different superscripts on the same line indicate differences significant ($P<0.05$).
L0 = Chicken sausage composition of 15% tapioca flour, 0% chia seed flour, and 0% carrot flour.
L1 = Chicken sausage composition of 11.25% tapioca flour, 3% chia seed flour and 0.75% carrot flour.
L2 = Chicken sausage composition of 7.5% tapioca flour, 6% chia seed flour and 1.5% carrot flour.
L3 = Chicken sausage composition of 3.75% tapioca flour, 9% chia seed flour and 2.25% carrot flour.
L4 = Chicken sausage composition of 0% tapioca flour, 12% chia seed flour and 3% carrot flour.

Table 3. Chemical quality of chicken sausage using chia seed flour and carrots flour on different levels.

Parameters	Treatments					*P value*
	L0	L1	L2	L3	L4	
Lipid	3.84±0.48^{c}	4.07±0.65^{c}	4.95±0.25^{b}	4.87±0.25^{b}	6.09±0.12^{a}	0.00
Protein	21.36±0.57^{b}	21.72±0.52^{ab}	22.23±0.22^{a}	21.89±0.39^{ab}	21.30±0.37^{b}	0.00
Water	66.53±0.71^{a}	66.68±1.17^{a}	66.26±1.14^{a}	63.95±0.58^{b}	65.96±1.07^{a}	0.01
Collagen	2.16±0.15^{b}	2.45±0.21^{ab}	2.58±0.22^{a}	2.75±0.19^{a}	2.16±0.28^{b}	0.00

^{a,b}Different superscripts on the same line indicate differences significant ($P<0.05$).
L0 = Chicken sausage composition of 15% tapioca flour, 0% chia seed flour, and 0% carrot flour.
L1 = Chicken sausage composition of 11.25% tapioca flour, 3% chia seed flour and 0.75% carrot flour.
L2 = Chicken sausage composition of 7.5% tapioca flour, 6% chia seed flour and 1.5% carrot flour.
L3 = Chicken sausage composition of 3.75% tapioca flour, 9% chia seed flour and 2.25% carrot flour.
L4 = Chicken sausage composition of 0% tapioca flour, 12% chia seed flour and 3% carrot flour.

flour in processed chicken sausage products had a very significant effect (P<0.01) on water, fat, protein, and collagen content. Treatment of 3% chia seed flour and 0.75% carrot flour (L1), 6% chia seed flour formula and 1.5% carrot flour (L2), and12% chia seed flour formula and 3% carrot flour (L4) were not different in water content compared to the control group (L0). Meanwhile, treatment with 9% chia seed flour and 2.25% carrot flour (L3) caused a decrease in sausage moisture content with a value of 63.95% compared to L0 (66.53%). An increase in sausage fat content was seen in the treatment of 6% chia seed flour and 1.5% carrot flour (L2), and the highest fat content was achieved in the treatment of 12% chia seed flour and 3% carrot flour (L4) at 6.09%. Treatment of 6% chia seed flour and 1.5% carrot flour (L2) caused an increase in sausage protein content with a value of 22.23% compared to L0 (21.36%). In general, there was an increase in collagen levels along with the increase in the use of chia seed flour in the range of 6-9% and carrot flour 1.5-2.25% (L2 and L3), however there is no difference in collagen content with the use of 12% chia seed flour and 3% carrot flour (L4).

Hedonic testing

The panellists' level of preference for chicken nuggets containing chia seeds and carrot flour is shown in Table 4.

The results of the analysis of variance indicated that the use of chia seed flour and carrot flour as a substitute for tapioca flour had a significant impact (P<0.05) on the level of preference for colour, aroma, taste, aroma, tenderness, texture, and overall preference for chicken sausages. Further test results showed that increasing the use of chia seed flour by 9% and carrot flour by 2.25% or more decreased the level of consumer preference for colour, aroma, taste, and flavour. The findings indicated that the more chia seed flour and carrot flour were used, the darker the sausage colour would be. The average preference score for the colour of chicken sausages was 5.40 (L0, neutral), 6.05 (L1, slightly like), 4.70 (L2, neutral), 4.05 (L3, slightly dislike), and 4.0 (L4, slightly dislike).

The results indicated that increasing the use of chia seed flour and carrot flour decreased the level of aroma preference from 6.05 (L0, slightly like) to 4.5 (L3, slightly dislike). The taste preference score of chicken sausage decreased along with the increasing use of chia seed flour and carrot flour from a score of 6.75 (L0, like) to 4.12 (L3, slightly dislike). The panellists gave the same assessment of the level of sausage taste preference between treatments L0, L1, and L2. Similarly, increasing the use of chia seed flour and carrot flour can reduce the level of consumer preference for flavour seen in treatments L3 and L4. The average score for the level of preference for the flavour of chicken sausage was 6.80 (L0, like), 5.75 (L1, slightly like), 6.0 (L2, slightly like), 5.10 (L3, neutral), and 4.15 (L4, slightly dislike). The findings indicated increasing the use of chia seed flour and carrot flour, up to levels 6 and 1.5%, respectively (L2), increased the level of consumer preference for sausage tenderness. The average score of the level of preference for chicken sausage tenderness increased from 5.49 (L0, neutral) to 6.35 (L2, slightly like). Increasing the use of chia seed flour to 12% and carrot flour to 3% (L4) decreased the level of consumer preference for sausage texture. The average score of the level of preference for chicken sausage texture decreased from 5.95 (L0, slightly like) to 4.65 (L4, neutral). The overall level of liking decreased with the increasing use of chia seed flour and carrot flour, which was seen in treatments L3 and L4. The average score of the overall liking level for chicken sausage was 6.55 (L0, like), 6.25 (L1, slightly like), 6.25 (L2, slightly like), 5.05 (L3, neutral), and 4.35 (L4, slightly dislike).

Discussion

The pH values which are not different by the inclusion of chia seed flour up to a level of 9% and carrot flour 2.25% are likely due to the relatively similar pH values of the fillers used to sausage products. Chicken, the main ingredient, has a pH ranging from 6 to 7 (BSN, 2009). The pH value of the filler combination used is relatively similar to the pH of chicken sausage (6.12-6.20). This opinion is supported by the statement of Soeparno (2011) that if the basic ingredients and supporting ingredients of processed meat products have the same pH value or a small variation, then the final product will also have a relatively similar pH. The pH value of chicken sausages with chia seed flour and carrot flour substitutes in this study ranged from 6.12 to 6.20. These findings are in line with the study by Khan and Ahmad (2015), which found that fresh horse meat sausage samples containing carrot powder up to a level of 5% had pH values ranging from 6.132 to 6.412. It was concluded that the chicken sausages from this study were still within the normal range.

No difference in water holding capacity is likely because the pH value of sausages relatively similar among treatments, resulting in similar water-holding capacity values. This is supported by Sofiana (2012) who reported that pH is a factor influencing the water-holding capacity of sausages. The water holding capacity that is not different is probably also due to the fact that there is no difference in the particle size of the flour used. For the purposes of this study, all flour utilized was of the same particle size, 80 mesh food grade material. Some researchers stated that in food ingredients, the water holding capacity can be determined by the particle size, porosity, and structure of the ingredient (Zhang *et al*., 2014; Shin and Choi, 2022). Porosity affects water holding capacity, where low porosity will produce low absorption capacity, and vice versa, if the porosity of a particle is high it will also produce high water absorption capacity (Farhana *et al*., 2014). A study conducted by Zhang *et al*. (2014) reported that sausage containing 5% (w/w) acetate starch exhibited suitable structure and pore size for water retention. Consequently, the sausage containing 5% (w/w) acetate starch exhibited the superior water-holding capacity

Table 4. Average hedonic test for chicken sausage using chia seed flour filler and carrot flour at different levels using 35 panellists.

Parameter	Perlakuan (Mean±SD)					*P value*
	L0	L1	L2	L3	L4	
Aroma	6.05±1.57^{a}	5.65±1.31^{ab}	5.25±1.30^{abc}	4.50±1.39^{bc}	4.35±1.49^{c}	0.00
Color	5.40±1.79^{ab}	6.05±1.10^{a}	4.70±1.26^{bc}	4.05±1.50^{c}	4.00±1.21^{c}	0.00
Taste	6.75±0.97^{a}	6.10±1.12^{ab}	6.20±0.95^{ab}	5.12±1.60^{bc}	4.50±1.23^{c}	0.00
Flavor	6.80±0.95^{a}	5.75±1.33^{ab}	6.00±0.97^{ab}	5.10±1.71^{bc}	4.15±1.09^{c}	0.00
Tenderness	4.90±1.80^{b}	6.40±0.82^{a}	6.35±0.81^{a}	5.90±1.52^{ab}	5.60±1.31^{ab}	0.00
Texture	5.95±1.32^{a}	6.25±0.85^{a}	5.95±1.23^{a}	5.40±1.60^{ab}	4.65±1.56^{b}	0.00
Overall	6.55±0.94^{a}	6.25±1.16^{a}	6.25±0.91^{a}	5.05±1.43^{b}	4.35±1.09^{b}	0.00

^{a,b}Different superscripts on the same line indicate differences significant (P<0.05).
L0 = Chicken sausage composition of 15% tapioca flour, 0% chia seed flour, and 0% carrot flour.
L1 = Chicken sausage composition of 11.25% tapioca flour, 3% chia seed flour and 0.75% carrot flour.
L2 = Chicken sausage composition of 7.5% tapioca flour, 6% chia seed flour and 1.5% carrot flour.
L3 = Chicken sausage composition of 3.75% tapioca flour, 9% chia seed flour and 2.25% carrot flour.
L4 = Chicken sausage composition of 0% tapioca flour, 12% chia seed flour and 3% carrot flour.

among pig sausages. This finding of the current study is in accordance with research by Vatria and Nugroho (2022) who reported that the addition of soy protein isolate levels of 0, 5, 10, 15 and 20% had no significant effect on the water holding capacity of tilapia sausages.

The cooking loss value decreased from 1.91% (L0) to 1.03% (L3). This indicates that the addition of chia seed flour at 9% and carrot flour at 2.25% (L3) to chicken sausages resulted in a good quality product due to low cooking losses. This indicates that the product has the potential to lose less water and other nutrients during the cooking process. This is in accordance with Soeparno (2011) who states that meat with low cooking losses has better quality because there is less loss of nutrients during cooking. The results obtained are likely due to the protein content in chicken sausage. The protein content of sausage products is estimated to increase as the concentration of chia seed flour and carrot flour is added. This opinion is supported by research by Ayerza and Coates (2009) who found that meat products containing 4% chia seed flour can increase the protein content of sausages which is higher than commercial products. This protein can influence the reduction and increase of cooking loss because protein is able to bind water, the more water retained by the protein, the less water is released so that cooking loss is reduced (Irawati *et al*., 2015).

The difference in cooking loss values between L0 and L3 in this study may also be caused by the mucus content in chia seeds. This chia seeds mucus contains hydrocolloid substances which are able to retain water, so the use of components with hydrocolloid properties such as chia seeds mucus is very important because it reduces excessive shrinkage in the cooking process of processed meat products (Chaves *et al*., 2018). The slime structure of chia seeds which acts as a soluble fiber can also provide hydration and viscosity development for food products (Vazquez-Ovando *et al*., 2009). In this study, it is also possible that there was an increase in fiber content along with the use of added levels of ingredients, thereby reducing the value of cooking loss, thereby causing an increase in the quality of cooking loss. A high amount of dietary fiber can cause a decrease in cooking losses of meat products. Dietary fiber added to meat products can reduce losses during cooking due to its ability to bind water and fat (Choi *et al*., 2009). Chia seeds have a fiber content of 18-30% (Tiwari and Shankar, 2023). This is supported by the research results of Arifin *et al*. (2021) who reported that the use of chia seed powder substitution at levels of 0, 5, 10, and 15% in the chicken sausage formulation could increase the product fiber content. The fiber contained in chia seeds is soluble fiber in water (Adawiyah *et al*., 2022). The fiber in chia seeds has the ability to form a gel which affects the yield so that the amount of water bound to the sausage will be greater. This is in accordance with the opinion of Wirjatmadi *et al*. (2002) that water-soluble fibre tends to mix with water to form a gel network (like agar) or a thick network.

The findings of this research are in accordance with the opinion of de Melo *et al*. (2015) who reported that the cooking loss value decreased significantly along with the increasing use of chia seeds in beef burger products. The cooking loss value of chicken sausages produced with an increase in the use of chia seed flour up to 9% and carrot flour up to 2.25% was 1.91-1.13. The results of this study have the same cooking loss range as the study by Suryaningsih (2002) which was 2.31-1.91 with the use of soybean flour content up to 30% in beef nuggets. This indicates that the cooking loss value from this study is still within the normal range.

No differences in tenderness obtained are probably due to the sausage processing using not too much vegetable filler, namely a maximum of 3% so that it does not reduce the level of tenderness. Vegetables and fruit contain high water content and do not have the ability to bind water so that if given in large enough quantities it will result in a reduce in the tenderness value, but if the addition is relatively small it will not affect the tenderness value. This opinion is in accordance with Prismadyanti (2015) who stated that adding carrots to meatballs can reduce the tenderness value, but if the addition of carrots to the meatballs is no more than 6% it will not affect the tenderness value. Tenderness values can also be influenced by pH and water holding capacity. The results of this study showed that the pH value is relatively the same in the range of pH 6 and the water holding capacity is not significantly different, especially in the WHC of raw sausages in all treatments. The WHC of cooked sausages up to the treatment of adding chia seed flour at a level of 9% and carrot flour 2.25% did not produce a difference in WHC values compared to the control group. This is one of the factors causing no significant difference in tenderness values. The pH value can affect the tenderness of a product by loosening the muscle structure, especially the actin and myosin bonds. The higher the density of the matrix structure, the higher the tenderness value (Soeparno, 2011) while according to Sujarwanta *et al*. (2016) the higher the water holding capacity of sausages, the more tenderness and juiciness will increase. This statement is supported by Ming-Min and Ismail-Fitry (2023) who stated that determining pH is crucial in evaluating the quality of meat products because WHC is strongly influenced by pH values, which in turn affect tenderness and microstructure. In this study, there was no difference in pH and WHC, thus, it did not affect tenderness. The results of this study yielded tenderness values ranging from 10.3 to 11.6. These results are relatively similar to those of Prismadyanti (2015), who found that using up to 12% carrot flour in rabbit meatballs resulted in tenderness values ranging from 6.1 to 9.63. The tenderness values in this study are within the normal range.

The results of water content obtained from this research probably occurred because the water content of the sausage was influenced by the water content contained in the filler. L3 treatment is able to reduce the water content in chicken sausages, this is likely because the water content of chia seed flour and carrot flour is low, so that if added to the sausage formula it can reduce the water content in other ingredients. This is supported by research by Tjahjadi (2013), who found that carrot flour has a water content of 5.6%. Meanwhile, Arumsari and Sofyaningsih (2020) reported that chia seed flour only contains 6.08%. Chia seeds' role as a gelling agent reduces the very high water content caused by the mucilage content (Suri *et al*., 2016) in processed sausage products. The results of this study are in accordance with research by Mohamed and Safaa (2019) who reported that the higher the use of chia seeds of 2-6% in processed sausage products, the lower the water content. Adding chia seed flour up to 9% and carrot flour up to 2.25% can reduce the water content by 63.95%. The water content is still in accordance with SNI 3820:2015, namely the maximum sausage water content is 67%.

Increasing the provision of chia seed flour resulted in an increasing trend in sausage fat content. This is likely due to the relatively high fat content of chia seed flour so that the more chia seed flour added to the chicken sausage processing can increase the fat content of the sausage. Arumsari and Sofyaningsih (2020) reported that chia seed flour has a fat content of 32.59%. Research conducted by Arifin *et al*. (2021) reported that control samples of sausage products had lower fat content when compared to products with 5-15% chia seed flour. Fernández-López *et al*. (2019) also support this, as they discovered that the incorporation of 3% chia seed flour into frankfurters resulted in higher fat content compared to the control samples. The fat content of chicken sausage obtained in this study was 3.84 to 6.09% which indicates that the fat content of chicken sausage complies with the SNI quality standards as the maximum fat content of chicken sausage should be 20%.

The increase in protein content with the addition of chia seed flour and carrot flour could be attributed to the relatively high protein level of chia seeds, in which the protein level was 15-25% (Chen and Luo, 2024), and carrot flour which contained 7.89% protein (Tjahjadi, 2013). It was observed in the L2 treatment. The protein content in sausages is related to the type of chicken and the fillers used (Mastuti, 2008). Segura-Campos *et al*. (2014) reported that chia seeds are known to contain large amounts of protein, fat, and carbohydrates. This finding is in line with Rahmawati and Irawan (2021) who used red bean flour as a protein source and claimed that using 5-20% red bean flour could increase the protein content of chicken nuggets. The protein content of chicken sausage produced with

the addition of chia seed flour and carrot flour is 21.30 to 22.23%. This shows the protein content of the chicken sausages was within the range of Indonesian National Standard (SNI) 2015 which required a minimum of 13% qualitatively. Thus, chicken sausages with 6% chia seed flour and 1.5% carrot flour yield a formulated sausage which can be a high protein animal food.

The results of this study also align with those of Alhana and Tarman (2015), who demonstrated important findings regarding collagen protein content, which is also related to the protein content of sausages. Sausages and other processed meat products contain varying amounts of collagen and protein, with collagen accounting for approximately 30% of the protein (Rahman *et al*., 2021). Mazorra-Manzano *et al*. (2011) states collagen as a protein present in meat's connective tissues, and based on his arguments, it has been corroborated that higher protein content results in higher collagen content. In this study, the collagen content of chicken sausages ranged from 2.16 to 2.75% with the incorporation of chia seed flour and carrot flour. This finding is consistent with Borrajo *et al*. (2022), who observed that adding up to 2% chia seeds to dry fermented sausages increased collagen level from 1.85 to 2.97%.

Several other studies confirm the results of this study. The nutrition content of meat products is enhanced with chia seeds, which serves as a filler. The findings of Arifin *et al*. (2021) showed that the water content of chicken sausages could be enhanced with the inclusion of chia seeds to a certain level. Chomanov *et al*. (2022) also found that incorporating carrots at a specific level decreases water content in canned goat meat products. Similar results were noted with the addition of carrot pulp to beef, where the use of pulp at certain levels increased the protein content and reduced the water content (Richards *et al*., 2024).

The characteristic colour of chicken sausages may be affected by chia seed flour's color, which is blackish brown. Hernandez (2012) stated that chia seeds is brown, grey, white, and dark. This is further corroborated by the findings of Hanifah *et al*. (2021) which reported that greater proportions of chia seed powder substitution led to darker coloured sausages. The extent of the preference for the color of a product is determined by the color of the vegetable ingredients used, like the incorporation of carrots. The color of carrots is due to the content of β-carotene and can influence the colour of meat patties (Schifferstein *et al*., 2019). Higher amounts of carrots result in more yellowish coloration (Shi *et al*., 2024). This could lessen consumers' color preference. The findings from this study corroborate the findings from the study of Paula *et al*. (2019) that reported the substitution of fat with chia seeds led to a diminished preference among consumers for the taste of chicken hamburgers. The flavor of a food product is closely related to its odor and taste. The results of preference scores for flavor followed the same pattern as aroma and taste, with a reduction in preference for flavor with the incorporation of 9% chia seed flour and 2.25% carrot flour (L3). Several attributes that can influence the overall acceptance of a food product are aroma, taste, and flavor. The study found a decrease in acceptance of the aroma, taste, and flavor of chicken sausage with the addition of 9% chia seed flour and 2.25% carrot flour. This resulted in a decrease in overall acceptance of the sausage product.

These results align with previous studies. Patel *et al*. (2022) reported that adding a certain level of grated carrot to chicken patties can reduce sensory (hedonic) attributes such as general appearance, juiciness, flavour, and overall acceptability. Adding a certain level of carrot to rabbit meat nuggets results in a decrease in texture, taste, and overall attributes (Susanti *et al*., 2023). The use of chia seeds in shrimp bread to some extent can reduce sensory attributes such as color, taste, smell, and texture (Suarez, 2022). Richards *et al*. (2024) stated that adding carrot pomace to beef patties can maintain sensory attributes to a certain level, but increasing carrot pomace content can reduce attribute values, especially texture and flavor. Differences in sensory attributes can be caused by the color, fiber content, and aroma of the ingredients used (Richards *et al*., 2024). The fat content in ingredients influences flavor, aroma, and taste attributes. Fat, combined with fiber, also affects the texture of hamburger products, so that higher fiber content can reduce the sensory attribute impression in consumers (Soncu *et al*., 20215). The fiber content in carrots can cause differences in texture in meat products; higher fiber content can result in a softer texture, making it less desirable for consumers (Salehi, 2021).

Conclusion

It can be concluded that chia seed flour as a filler up to a level of 6% and carrot flour 1.5% can improve the chemical quality and can maintain the physical quality of chicken sausages. Chicken sausages containing substitute fillers of 6% chia seed flour and 1.5% carrot flour can be applied to produce chicken sausages while maintaining organoleptic quality.

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Conflict of interest

The authors have no conflict of interest to declare.

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