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Physicochemical and Sensory Properties of Goat Meat Sausages Prepared With Different Levels of Goat Liver

Endy Triyannanto[1*], Rusman[1], Meireni Cahyowati[2], Joseph Kayihura[3], Pradita Iustitia Sitaresmi[4]

[1]Department of Animal Product Technology, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia
[2]Livestock Production Technology Study Program, Politeknik Negeri Banyuwangi, East Java, Indonesia
[3]Advanced Food Systems Research Unit, Institute for Sustainable Industries and Liveable Cities, College of Health and Biomedicine, Victoria University, Melbourne, Vic 3030 Australia
[4]Research Center for Animal Husbandry, BRIN, Cibinong, West Java, Indonesia

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* Corresponding author:
E-mail: endy.triyannanto@ugm.ac.id

ABSTRACT

Anemia, a common issue among children and teenagers in Indonesia, is characterized by hemoglobin levels below normal. Iron is essential for producing hemoglobin in red blood cells, which helps prevent anemia. Innovation to provide a popular goat liver-based product that is convenient to consume and easily marketable underpins the development of this goat liver-enhanced sausage. The aim of this research was to determine the effect of partially substituting goat meat with different levels of goat liver on physicochemical and sensory properties of goat meat sausages. Sausages containing 100:0, 75:25, and 50:50 goat meat to goat liver ratios and goat meat (%, w/w) , and then added with other ingredients (tapioca flour, skim milk, garlic, pepper, coriander, salt, STPP, and ice water) were prepared and cooked for 30 minutes. The sausages were then analyzed for physical properties, including pH, texture and water holding capacity (WHC), iron content, and sensory quality. Data were analyzed using analysis of variance for a completely randomized design, and then if there were significant differences between means, they were tested using Duncan's New Multiple Range Test. The results showed that substitution of goat liver significantly ($p<0.05$) increased the pH, WHC, and iron and fat contents of goat meat sausages. The highest levels of iron content (32.89 mg/kg) and WHC (45.20%) of the sausages were obtained at a 50:50 ratio of goat meat to goat liver whereas the hardness, gumminess and chewiness decreased with increasing proportion of goat liver. On the contrary, the impact on water, protein and collagen contents, and sensory quality (except tenderness) was not significant ($p>0.05$). In conclusion, substituting up to 50% of goat meat with goat liver will improve the iron content of goat meat sausages with minimal impact on the sensory and proximate composition of the product.

Keywords: *Goat Liver, Goat Meat, Iron Levels, Physical Quality, Proximates Content, Sausages, Sensory*

Introduction

Anemia is a common problem in Indonesian children and teenagers. It is a condition in which hemoglobin levels in human red blood cells are below the normal range. Arnanda *et al*. (2019) stated that the normal range of hemoglobin levels is 13-18 g/dL or 12-16 g/dL in men and women, respectively. A person can have severe anemia if the iron intake they consume does not meet their needs because iron is an essential micromineral element that is important as a hemoglobin regulator. The prevalence of anemia in 2013 at one university in Palembang reached 37.01% and increased in 2018 by 48.09%, with the majority occurring in young women panelists at a maximum age of 24 years (Contessa *et al*., 2022). These data show that the prevalence of anemia is still relatively high.

Efforts can be made to reduce the prevalence of anemia, especially among teenagers, by consuming foods rich in iron, such as goat meat. Goat meat contains iron, but consumption levels among teenagers are still low because of the distinctive aroma of goat meat. Therefore, innovative goat meat restructuring is needed in order to improve its acceptability, and one form of processed goat meat product that has undergone restructuring is sausage, which is in demand among teenagers.

Sausage is a type of processed meat product that is made by mixing finely ground meat with other ingredients, then putting the mixture in a casing and further processing (Martin and Garden, 2004). Based on USDA (2001), 100 g of goat meat

contains 122 kcal calories, 2.6 g of fat, 0.79 g of saturated fat, 23 g of protein, and 63.8 mg of cholesterol. Goat meat only contains 3.2 mg of iron so goat meat sausages can be used to increase iron intake in teenagers. However, goat meat is relatively expensive. Therefore, other ingredients are needed that are similar in quality to goat meat without reducing the benefits and changing the taste of goat meat sausage. One ingredient that can be used as a meat substitute is goat liver.

Goat liver has an iron content of 7.78 mg/100 g (Tomović *et al*., 2017). Goat liver can be an alternative ingredient that can be added to making goat meat sausages, considering its high iron content, so the use of goat liver is expected to increase the iron content of the goat meat sausages. Goat liver also has different physical characteristics from goat meat. Goat liver has a higher fat content than goat meat, reaching 6.27 g/100 g; it can, therefore, affect the final texture of the sausage produced. It is hoped that this sausage, which is made with a mixture of goat meat and goat liver, can become a type of innovative processed meat food as an acceptable source of iron and fulfil iron needs, especially among teenagers. Therefore, the aim of this study was to determine the effect of different proportions of goat meat and goat liver in the formulation on the iron and proximate composition as well as on the physical and sensory qualities of goat meat sausages.

Materials and Methods

Material

Tools used include knives, steaming pans, scales, meat grinders (MM 32 Mahkota, Indonesia), choppers, stuffers, stoves, pans, thermometers, beakers, pH meters (Mettler Toledo model FiveEasy TM F20, Switzerland), filter paper, ovens, 35 kg loads, glass plates, texture analyzers (TA. XT plus C (SMS TA50/650L), UK)., atomic absorption spectrophotometers, volumetric flask, microwave digester, questionnaire, and NIRS Foodscan. The ingredients used include goat meat and goat liver, which came from under 1-year age-old Bligon goat, slaughtered with the halal method, garlic, skim milk, tapioca flour, pepper, coriander, STPP, ice water, and collagen casings. Materials for testing include filter paper, distilled water, and 65% HNO_3 solution.

Methods

Sausage making

Goat meat that was cut into small pieces and cleaned of connective tissue was ground using a meat grinder. The goat's liver was also cleaned, then cut into small pieces and ground using a meat grinder. Finely ground goat meat and liver were weighed according to the formulation of each treatment. The ratio between goat liver and goat meat was 0%:100%, 25%:75%, and 50%:50%.

Tabel 1. Formulation of goat meat sausages with goat liver substitution

Proportion (g)	Ingredient Sausage Ratio of Goat Liver and Goat Meat		
	0%:100%	25%:75%	50%:50%
Goat Liver	0	82.5	165
Goat meat	330	247.5	165
Garlic	120	120	120
Skim Milk	10.98	10.98	10.98
Tapioca Flour	3.48	3.48	3.48
Pepper	2.04	2.04	2.04
Coriander	7.98	7.98	7.98
Sodium Tripolyphosphate	10.98	10.98	10.98
Ice Water	1.02	1.02	1.02

The ground goat meat and liver were then mixed with the enveloping ingredient in the form of skim milk. The dough containing tapioca flour and other ingredients, including salt, pepper, garlic, coriander, and STPP, was added. Ice was added to the mixture and mixed using a chopper, then put into a collagen casing. Sausages were steamed at 100˚C for 30 min. The cooked sausages were removed and steamed before testing.

Physical quality

The physical properties of goat meat sausages include pH value, water holding capacity (WHC), texture profile, and iron content.

pH value. pH value tested according to Bouton et al. (1971), i.e., 2 g of sausages were weighed, ground, and dissolved in 18 ml of distilled water until homogeneous. A calibrated pH meter was placed in the sample until the pH of the sausage was constant.

Water holding capacity (WHC). The WHC of goat meat sausages was tested using the modified Hamm (1986) method. WHC then calculated based on the formula:

$$\text{WHC}(\%) = \frac{\text{Retained Water Weight (g)}}{\text{Initial Sample Weight (g)}} x100\%$$

Texture profile. The sausage texture profile was tested using a texture profile analyzer with a P35 cylindrical probe, strain mode with a compression level of 40%, and a probe speed of 5 mm/s. Physical quality testing was carried out five times for each treatment.

Iron content. Analysis of the iron content of sausages was tested by destroying the samples using the microwave digester method, then the iron content in the sausage samples was analyzed using an atomic absorption spectrophotometer at a wavelength of 248.3 nm. Testing for iron contents was carried out four times for each treatment.

Moreover, proximate analysis was conducted by using NIRS-Foodscan.

Sensory analysis

The panelists used for the sensory test were untrained panelists who filled out a questionnaire. Sensory analysis that used in the research, such as color, aroma, tenderness, flavor, and acceptability. The parameter scale was set at a score of 1-5.

Data analysis

Data on physical quality and iron and proximate content of goat meat sausages were analyzed using analysis of variance for completely randomized and significant differences between means were tested using Duncan's New Multiple Range Test (Steel and Torrie, 1993). Data on the sensory quality of goat meat sausages were analyzed using non-parametric Kruskall Wallis analysis, and significant differences between means were tested using the Mann-Whitney Test.

Results and Discussion

Physical quality

The results of physical quality tests including pH value, texture profile, and WHC of goat meat sausages substituted with goat liver are presented in Table 2.

Table 2. Physical qualities of goat meat sausages with goat liver substitution

Parameters	Goat liver balance level: goat meat (%)		
	0:100	25:75	50:50
pH	6.46±0,04^{a}	6.63±0,04^{b}	6.66±0,03^{b}
Texture Profile			
Hardness (g)	17.04±0,95^{b}	14.85±1,09^{b}	11.57±2,26^{a}
Gumminess	13.18±0,54^{b}	11.24±1,06^{b}	9.28±2,13^{a}
Chewiness	12.96±0,96^{c}	10.05±1,74^{ab}	8.40±2,06^{a}
Springiness (%)^{ns}	90.64±0,66	90.69±1,03	89.83±2,02
WHC (%)	41.87±0,52^{a}	43.14±1,01^{ab}	45.20±0,53^{c}

^{a,b,c} different superscripts with the same row indicate significant differences ($p<0.05$)
^{ns} not significant ($p>0.05$).

pH value. Substitution of goat meat with goat liver at different ratios showed a significant difference in the pH value of sausages ($p<0.05$). The higher level of goat liver substitution in making goat meat sausages caused an increase in the pH value of the sausage. Soeparno (2015) stated that the basic and other ingredients used for making sausages have the same pH value, so the final product will also have relatively the same pH or the variations will be small or large. Goat liver has a pH range at 6.5-6.6 which is higher than that of goat meat (5.3-5.8). Therefore, the level of substitution of goat meat with goat liver caused an increase in the pH of the sausages produced because according to Laksmi (2012), the pH of the raw materials used to make sausages will also affect the pH value of the sausages. As a comparison, the pH of goat meat sausages in a study conducted by Massingue *et al*. (2018) ranged from 6.30-6.46, and in Suryaningsih's research (2017), the pH value for goat meat sausages reached 6.77.

Texture profile. Substitution of goat meat with goat liver at different ratios showed a significant difference in the sausage texture profile including hardness, gumminess, and chewiness ($p<0.05$), but no significant difference in the springiness value ($p>0.05$) was found. The hardness of goat meat sausage decreased with the increased proportion of goat liver. The liver has a fat content of 6.27 g/100 g and goat meat has a fat content of 2.6 g/300 g. The high fat content in goat liver caused goat meat sausages with goat liver substitution to become more tender (Apriantini *et al*., 2021). Moreover, beef liver has a soft texture, making it very easy to break down (Astawan, 2012). Apart from that, the high water content in goat liver also causes the hardness value to decrease.

The gumminess of goat meat sausage $p<0.05$ decreased along with an increasing proportion of goat liver. The hardness of the sausage obtained affects the size of the gumminess value. Apriantini *et al*. (2021) stated that when a sausage is easy to crush when chewing, it indicates that the gumminess value of the sausage is low, one of the causes is the low hardness value. The lower gumminess value with the increase in the proportion of goat liver indicates that the sausage is not too gummy and sticky.

The chewiness of goat meat sausage $p<0.05$ decreased with increasing proportion of goat liver Apriantini *et al*. (2021) stated that chewiness is the chewing power of a sausage product until the product is destroyed by chewing. Moreover, the elasticity of sausages is influenced by one of the contents of hardness of the sausage and its level of elasticity. The lower chewiness value indicates that the sausage is not too chewy and the texture is softer (Setiaboma *et al*., 2021).

The springiness of goat meat sausages showed results that were not significantly different ($p<0.05$). The springiness or elasticity value of sausages is influenced by the stability of the sausage product emulsion which is influenced by the components and ingredients that make up the sausage (Prijambodo *et al*., 2014). Cruxen et al. (2018) state that it can be seen that the use of the type of material will also affect the texture of the final product produced.

Water Holding Capacity (WHC). Substitution of goat meat with goat liver at different ratios showed a significant difference in the water-holding capacity value of goat meat sausages

(p<0.05). The WHC of goat meat in this study was 41.87%-45.20%. Increasing the substitution of goat meat with goat liver causes an increase in the WHC of goat meat sausages. Goat liver protein contents reached 23.1 g/100 g (Toit *et al*., 2018). Soeparno (2015) states that the WHC will also be influenced by the pH value of the meat product when the proteins in the meat have a pH isoelectric point between 5.0-5.1 and if the pH is higher or lower than the isoelectric point of the meat protein which results in an increase in WHC.

Iron contents

The test results for the iron content of goat meat sausages substituted with goat liver in different balances are presented in Table 3.

Table 3. Iron content of goat meat sausages with goat liver substitution

Parameter	Goat liver balance level: goat meat (%)		
	0:100	25:75	50:50
Iron level (mg/Kg)	24.48±4,44[a]	30.51±6,57[ab]	32.89±0,91[b]

[a,b] different superscripts with the same row indicate significant differences (p<0.05)

The results of iron content in goat sausages, which were substituted with goat liver, showed a significant difference (p<0.05). The real difference was that goat liver contains a good source of minerals, especially iron (Srebernich *et al*., 2015). The iron contained in liver innards is higher than the iron in meat. The iron contained in goat liver viscera is 7.78 mg/g (Tomović *et al*., 2017) whereas according to (Srebernich *et al*., 2015) the iron content in goat meat is 3.2 mg/300 g.

The high level of iron in liver viscera causes an increase in the iron contents in sausages. The iron contained in hemoglobin is classified as heme iron. Heme iron in hemoglobin, which originates from a protein compound, undergoes an initial reaction process in the small intestine. When protein compounds in the small intestine undergo a separation process it will separate the heme iron from the structural bonds of protein compounds. This separated heme iron will be absorbed by small intestinal enterocytes. Then, heme iron will undergo an oxidation process by the heme oxidase enzyme to become ferrous and porphyrin (Ayuningtyas *et al*., 2022). Then, ferrous compounds will undergo oxidation to become ferric compounds. This ferric compound will increase heme iron in the blood there by treating anemia in teenagers (Ayuningtyas *et al*., 2022).

Proximate content

The results of proximate analysis tests including water, fat, protein, and collagen of goat meat sausages substituted with goat liver are presented in Table 4.

Table 4. Proximate analysis of goat meat sausages with goat liver substitution

Parameters	Goat liver balance level: goat meat (%)		
	0:100	25:75	50:50
Water (%)[ns]	64.62±0,69	68.15±2,24	67.82±4,02
Fat (%)	3.93±1,13[a]	4.79±0,64[b]	4.59±1,19[b]
Protein (%)[ns]	19.91±1,01	20.96±1,26	20.89±1,79
Collagen (%)[ns]	2.10±0,51	2.35±0,33	2.48±0,41

[a,b] different superscripts with the same row indicate significant differences (p<0.05).
[ns] not significant (p>0.05).

The results show that the addition of goat liver had no significant effect on water content. This was possible because the combination of goat liver and the addition of water and starch was balanced enough so it would not affect the water content of goat sausage. Liver is high in water content, it does imply that the tissue has a substantial amount of water, but WHC will depend on how well this water is retained within the tissue under various conditions. Rompis and Londok (2022) stated that sausage requires water as an important component because it affects its appearance, texture, and flavor. in addition, the research data showed that there was no significant effect on the protein content. This could possibly occur due to the amount of added starch in the sausage dough whose proportion was balanced so as not to affect the protein content of the sausage. Rompis and Londok (2022) stated that the amount and type of meat are the main raw materials needed and are closely related to sausage products. Sausage is made with meat grinding treatment so that there is an expansion of the meat surface, and it is easier for the extraction of protein myofibrils and dissolves the protein. On the other hand, there was a significant effect on the fat content of the sausages as the fat content in the liver was higher than the fat content in the meat.

This significant effect is supported by Nadirah, (2019) who stated the sample that uses the highest amount of liver addition then the higher the fat content. According to Tomović *et al*. (2017), the fat content in goat liver is quite high i.e., up to 3.41%. The use of collagen-based casings has no significant effect (p>0.05) on the chemical characteristics of sausages. It is possible that the presence of collagen in the casings is covered by a higher content of water, fat, and protein than contained in collagen casings. Farida and Amaliah (2019) explained that casings derived from collagen have a lower ability to medium water absorption in sausages when compared to casings using cellulose materials.

Sensory Evaluation

The results of sensory evaluation tests of goat meat sausages substituted with goat liver are presented in Table 5.

Table 5. Sensory evaluation of goat meat sausages with goat liver substitution

Parameters	Goat liver balance level: goat meat (%)		
	0:100	25:75	50:50
Color (%)[ns]	3,37±0,94	3,14±0,85	3,23±1,00
Aroma (%)[ns]	3,06±1,11	2,97±1,20	3,06±1,14
Tenderness (%)	2,83±1,01[a]	3,14±0,91[a]	3,80±1,02[b]
Flavor (%)[ns]	3,34±0,94	3,26±1,09	3,40±0,98
Acceptability (%)[ns]	3,20±0,93	3,17±0,95	3,37±1,06

[a,b] different superscripts with the same row indicate significant differences ($p<0.05$).
[ns] not significant ($p>0.05$).

The results showed that there was no significant effect of substituting goat meat with goat liver on sausage color, aroma, taste, and acceptability ($p>0.05$). There was no significant effect of goat liver substitution on the color of the sausage possibly because the amount of starch added in the sausage mixture was quite high compared to the amount of goat liver. This is supported by the statement of Purwosari and Afifah (2016) that the starch content contained in tapioca flour and cornstarch cannot affect the color of the sausage because starch can produce a transparent gel that covers the color of the sausage.

There was no significant effect on the aroma because the smell of liver offal is masked by the characteristic aroma of the seasoning used. The aroma of sausage is influenced by the spices in the sausage mixture. This is similar to research conducted by Sofyan *et al*. (2018), in which the addition of seasonings to the mixture, such as salt, pepper, nutmeg, shallots, and garlic, affected the aroma of mushroom sausage because these seasonings dissolve in water and boiling process so that the aroma of the resulting sausage is produced. The results showed a significant effect of goat liver offal on the tenderness of goat meat sausages ($p<0.05$). The data obtained showed that the goat meat sausages with goat liver substitution at a 50:50 ratio had the highest value than the other samples. The highest level of tenderness occurred because of the emulsion of fat in goat liver. This can occur because protein compounds contain polar groups that cause this protein-water phase to form a strong matrix bond. A strong protein-water matrix bond causes the capacity of the fat granules coated to be greater so that the emulsion process that occurs is higher. There was no significant effect on taste, which could be influenced by the seasoning and ingredients added. Rompis and Londok (2022) stated that factors that affect the flavor of sausage are salt, spices, sugar and fat added in the sausage. Acceptability was not influenced by goat meat substitution with goat liver. The parameters of consumer acceptance of the sausages included color, taste, aroma, and tenderness. This is in accordance with the insignificant data on the parameters of color, aroma, flavor, tenderness, and acceptability ($p>0.05$). Prayitno *et al* (2009) stated that acceptability is consumer acceptance based on sensory parameters of sensory characteristics of processed meat products.

Conclusion

It can be concluded that goat liver can substitute goat meat up to 50% in the making of sausages without altering sensory properties except texture and fat content.

Conflict of interest

The authors agree and there are no relevant conflicts of interest in this manuscript.

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Author's contribution

Author contributions to this study are as follows Conception and study design by ET and R. Analysis and interpretation of results by ET, R, MC, JK, PIS. Manuscript Preparation by ET and MC.

Ethics approval

Animal subject were not present in this article so there was no Animal Ethics Approval.

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