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EFFECT OF USING MORINGA SEED EXTRACT TO TENDERIZE LONGISSIMUS MUSCLE OF INDONESIAN NATIVE GOATS

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Abstract

Tenderness is one of meat's most important quality parameters in consumer perceptions. The tenderness of meat depends on various pre- and post-slaughter factors. The production of consistently tender meat is required to retain consumer confidence in red meat. Plant proteases offer a natural alternative to chemical tenderizers, aligning with consumer preferences for clean-label products without artificial additives. M. oleifera is highly nutritious and contains essential amino acids, vitamins, and phenolic compounds, and several studies have investigated the M. oleifera protein's enzymatic properties and found that it contains proteolytic enzymes. This study aimed to assess the effect of adding moringa seed extract on the tenderization of goat meat (Longissimus thoracis pars lumborum), where the extraction of M. oleifera seed extract was performed using 20 g of moringa seeds with 60 mL of distilled water. The meat was marinated in the extract, with each sample consisting of 100g of goat meat and 60ml of seed extract, and left in the refrigerator at 4°C for different periods (2-, 24-, and 46-hours marination T1, T2, and T3, respectively, with T0 as the control without any additives). PH, texture profile analysis, color, and cooking loss were measured. The results show significant differences between the pH of the control and the treated samples, with no significant differences in pH among the treated samples, as within the normal range that promotes tenderness without an adverse effect. Moringa seed extract increased the cooking loss value in treated samples compared with the control. There was also a significant effect on the texture

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profile, where a decrease in hardness, chewiness, toughness, and firmness was observed after two hours of marinating, which increased with longer marinating times of 24 and 46 hours. There was a significant difference between the control and the other treated samples in lightness and yellowness, as all treated samples exhibited an increase in lightness and a decrease in yellowness compared to the control. The effect of redness was not substantial in the control and 24- and 46-hour groups. However, the 2-hour group showed a significant difference compared to the control and the 24- and 46-hour groups. The results indicate that moringa seed extract can improve tenderness, with a 2-hour treatment showing the most positive outcomes for several textural characteristics, suggesting it could be a valuable natural tenderizer. Further research is needed into the optimal duration and amount required to tenderize meat without adverse effects.

Keywords: Moringa seed extract; meat tenderization; goat meat; texture profile analysis.

1. INTRODUCTION

Meat tenderness is a crucial attribute that significantly influences consumer satisfaction and acceptance. Thus, consistently tender meat is necessary to maintain consumer confidence in red meat, which competes with other types of meat that inherently do not have toughness issues, such as poultry and fish. The main factors affecting meat's toughness are the connective tissues, primarily collagen, and the myofibrillar proteins, myosin and actin. Therefore, meat tenderization weakens the connective tissue structure and loosens the protein structure of the myofibers. Thus, there is a growing interest in exploring natural alternatives, such as *Moringa oleifera*, for meat tenderization. Studies on *Moringa oleifera* have been conducted, but they are constrained, especially those focusing on goat meat tenderization, which is scarce. Most previous research has focused on other types of meat and used moringa as a supplement in many studies, leaving a gap in understanding how moringa impacts goat meat quality, particularly regarding tenderness. There is a lack of exploration into the biochemical mechanisms by which *Moringa* contributes to meat tenderization. Additionally, understanding the enzymatic activity or the impact of specific compounds in moringa that facilitate muscle fiber relaxation and collagen breakdown could provide valuable insights. *Moringa* is a tree with nutritional and medicinal properties, widely recognized for its health benefits. Ezzat et al., (2020) concluded that *Moringa* leaves aqueous extract exhibited potent antioxidant activity, while the seeds exhibited potent antimicrobial activity. Therefore, both *Moringa* extracts can be used as natural additives to improve the quality and safety of semi-dry fermented sausage. It contains various bioactive compounds, including proteolytic enzymes. *Moringa* has antimicrobial and antioxidant properties, making it a natural antimicrobial coating. It was used in raw chicken sausage to reduce the presence of E. coli and B. cereus, thereby delaying spoilage. This is attributed to phenolic acids disrupting bacterial cell membranes (Sharma et al., 2020). *Moringa* leaf powder can be used as a natural feed supplement for promoting growth, meat quality, healthy blood, and sound health in broilers (Akib et al., 2024). The proteolytic enzymes, including papain and bromelain, have received extensive research on their tenderizing effect on meat compared to other natural tenderizing agents. Likewise, Moringa seeds may contain enzymes capable of demonstrating possible tenderizing effects. *Moringa* leaves have been proven to possess a tenderizing action on goat meat. A fresh paste of moringa leaves was prepared and applied to goat meat samples, significantly improving the texture profile by reducing hardness and toughness (Mohamed et al., 2025). Although this study primarily focuses on the leaves, their enzymatic properties suggest that Moringa seeds may contribute to tenderization.

The tenderization process involves breaking down connective tissue and meat proteins, primarily collagen, which contributes to the toughness of meat. Moringa oleifera and fermented Moringa oleifera could improve broilers' flesh color and breast muscle tenderness (Jiang et al., 2023) The proteolytic enzymes in moringa seed extract may hydrolyze these proteins, making the meat tender. In addition to tenderization, moringa seed extract may enhance other meat quality characteristics. Dubeni et al., (2024), studied the potential of moringa leaf extracts as natural preservatives. By inhibiting microbial growth, these extracts can ensure the safety, quality, and shelf life of chicken meat. Das et al., (2024) It is suggested that immature moringa pods can serve as a natural, functional ingredient, improving meat products' nutritional quality and functionality while extending their shelf life through their antioxidant properties. The natural tenderizers papain and bromelain have been shown to improve the sensory attributes of meat, including flavor and juiciness (Hafez et al., 2024) (Orynbekov et al., 2024). Analogously, moringa seed extract may improve the sensory quality of goat meat. Though a tenderizing prospect of moringa seed extract is attractive, several limitations and considerations exist. The optimal concentration and application time have yet to be determined, as excessive enzymatic activity can lead to an undesirable, mushy texture (Mohd Azmi et al., 2023). The present study highlighted the potential benefits of *Moringa* seed for tenderization, and the texture profile analysis yielded new data on how moringa seed extract affects various textural attributes, such as hardness, chewiness, springiness, and overall mouthfeel, which are critical to consumer acceptance. Therefore, this study was designed to examine the impact of plant proteases from *Moringa* seed extract on the tenderization of goat meat. It also determined extraction methods, and the optimal concentration of *Moringa* seeds extract can be used as a tenderizer for goat meat. The parameters studied include cooking loss, texture profile, pH (acidity), and color.

2. MATERIALS AND METHODS

2.1 Materials

The primary research material consisted of goat meat, specifically samples from the Longissimus muscle. Longissimus dorsi muscle samples were collected between the 9th and 12th ribs on both the left and right sides, obtained from a meat shop after slaughter, transported to the lab, stored in the freezer for approximately one to two weeks, and then used. *Moringa* seeds are obtained from the marketplace. The study was conducted in the Animal Products Technology Laboratory and the Biochemical Laboratory at Jenderal Soedirman University, Purwokerto, Indonesia.

2.2 The Preparation of Moringa Seed Extract

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We weighed 20g of *Moringa* seed (for each sample), washed them, and soaked them in distilled water for 6hr; after that, we drained the water from them and ground the seeds using a mortar and pestle; we mixed grounded seed with 60 ml of distilled water and stirred them using a magnetic stirrer for 30 min with cold conditions, then was filtered using cloth, and centrifuged by centrifuge 7000rpm for 10 min, the supernatant used for meat samples marinade. The process of moringa seed extract manufacture can be observed in figure 1.

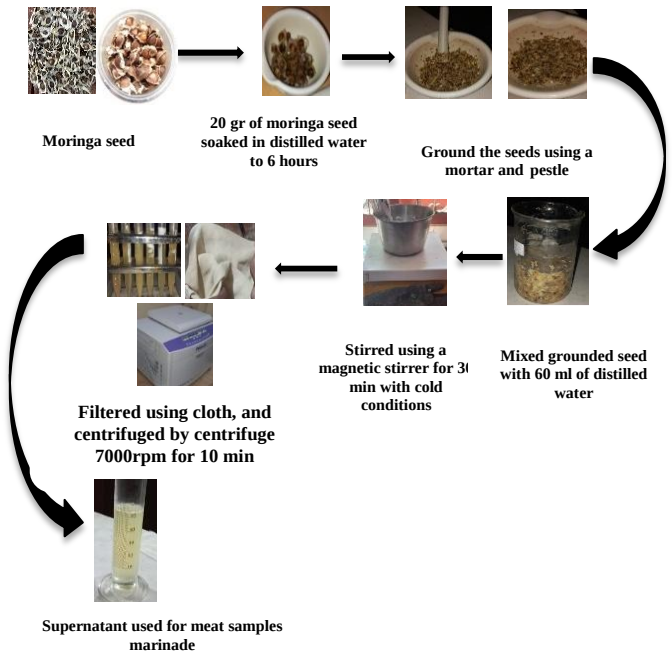

Figure 1. The process of moringa seed extract manufacture

2.3 Meat Sample Preparation

The meat samples were divided into four treatments (each 100g): T0: control without extract, T1; 2 hours marination, T2: 24 hours marination, and T3: 48 hours marination, with three replications. We marinated samples in the Moringa seed extract, ensuring they were covered on the entire surface. We saved them in glass containers and put them in the refrigerator at different times. The samples were analyzed for pH, instrumental color, cooking loss, and texture profile. Meat samples tenderization process with moringa seed extract can be observed in figure 2.

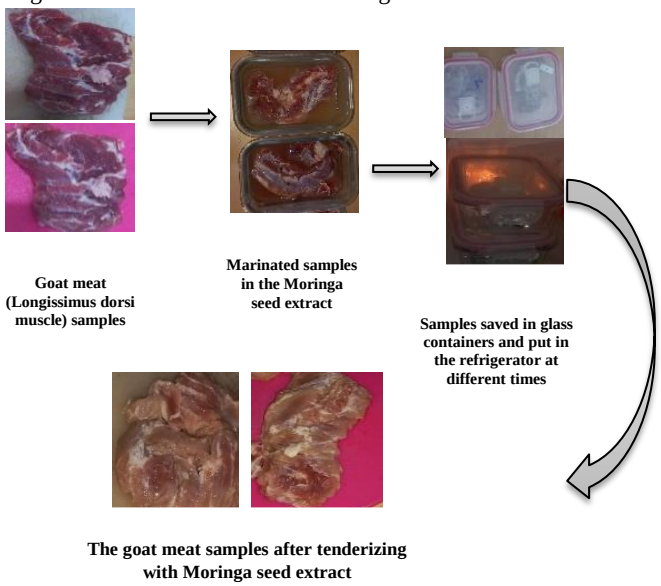

Figure 2. Meat samples tenderization process with moringa seed extract

2.4 Determination of pH

The measurement was performed by dipping a calibrated pH meter into a mixture of homogenized meat. All measurements were performed at room temperature.

2.5 Cooking Losses (CL)

We cut three cubes from each sample, weighed them, and placed each cube in a labelled plastic bag. Then, we cooked it in a water bath at 80ºC for 10 minutes. Then, cooked muscles were chilled, blotted dry, and weighed. The CL percentage will be determined using the equation "cooking loss percentage = ((initial sample weight - sample weight after cooking) / initial sample weight) × 100." (Honikel, 1998).

2.6 Texture Profile Analysis

Texture profile analysis of the meat was measured using the Food Texture Analyzer (TA-XT, Stable Micro Systems, Godalming, UK). An aluminum cylinder probe with a diameter of 40 mm was used. The experiments were conducted at room temperature with measurement conditions of 30% compression ratio and cross-head speeds of 1.0 mm/s and 2.0 mm/s. Meat samples were cut into uniform pieces to ensure homogeneity. Then, the meat samples were placed between the probe and the base. Parameters measured include hardness, springiness, cohesiveness, chewiness, gumminess, resilience, firmness, and adhesiveness.

2.7 Color

The colorimetric evaluation of samples treated and controlled was assessed for the colorimetric parameters L* (Lightness), a* (green to red coordinate), and b* (blue to yellow coordinate) using a Konica-Minolta CR-400 colorimeter.

2.8 Statistical Analysis

The obtained data were statistically analyzed using the SPSS program for Windows (Version 25) and tested with one-way ANOVA, followed by Duncan's multiple range test to compare the differences between means. Data are expressed as mean values ± standard deviation (SD). The accepted level of significance for all comparisons was $p<0.05$.

3. RESULTS

3.1 Effects of Moringa Seed Extract on the pH and Cooking Loss of Goat Meat

Table 1 shows significant differences in pH between the control and the 2-, 24-, and 46-hour treatments. However, there were no significant differences in pH among the 2-, 24-, and 46-hour groups.

There was a significant difference in cooking loss between the control and the 46-hour groups and a substantial difference between the 2-hour and 46-hour groups ($p < 0.05$). Additionally, no significant difference was found between the control and the 2-hour and 24-hour groups ($p < 0.05$). However, there was a substantial difference between the 24-hour and the 46-hour.

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Table 1. Acidity (pH) and cooking loss (means ± SD) affected by moringa seed extract during different tenderization time.

Item	Control	Tenderization period (hr.)		
	0	2	24	46
PH	5.88^{c} ± 0.24	6.13 ^{ab} ± 0.21	6.04 ^{ab}± 0.11	6.15^{a} ± 24
Cooking loss (%)	36.8 ^{c} ± 1.59	38.8^{bc} ± 2.0	39.7 ^{b} ± 2.4	42.7^{a} ± 1.4

Different letters (a, b, c) in the same row indicate significant differences between means (p 0.05).

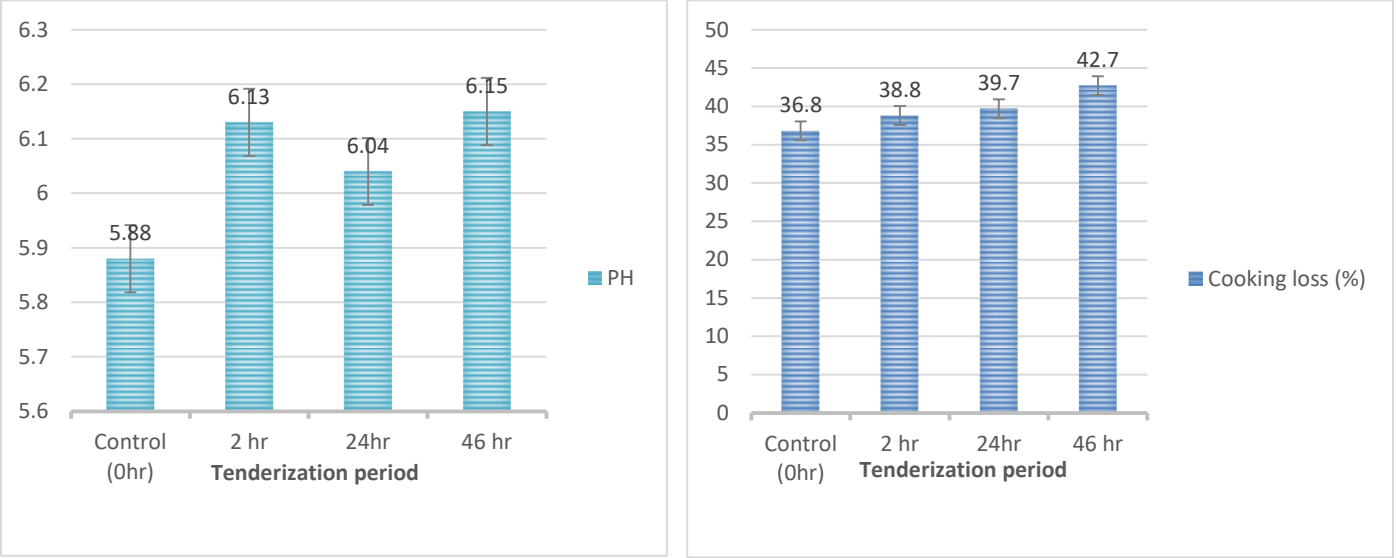

Fig 3. Acidity (pH) and cooking loss of goat muscle as affected by moringa seed extract

3.2 Effects of Moringa Seeds Extract on the Texture Profile of Goat Meat

Table 2 shows the texture profile analysis (TPA) parameters of the treatments (T0 (control), T1, T2, and T3) from longissimus muscle treated with Moringa seeds extract and stored for different durations (0-hour - control, 2-hour, 24-hour, and 46-hour) at a temperature of 4°C. There was a significant difference ($p < 0.05$) in the samples treated at 2 and 24 hours in hardness, resilience, and chewiness compared to the control. In contrast, no significant difference was observed in the samples treated at 46 hours compared with the control. The results show a substantial difference in the adhesiveness effect between the 2-hour treatment and the control. The 24-hour and 46-hour treatments exhibited intermediate levels of adhesiveness, which were not significantly different from each other or the control and 2-hour treatments individually. The control significantly differed in cohesiveness from the 2-hour treatment; simultaneously, the 24-to-46-hour and the 24-hour and 2-hour treatments were not significantly different. The analysis revealed significant differences ($p < 0.05$) in gumminess between the two 24-hour treatments and the control and between the 24-hour treatments and the 46-hour treatments. The analysis indicates a significant difference in toughness between the control and 24-hour treatment. The 2-hour and 46-hour treatments do not significantly differ from each other.

Table 2. Texture profile analysis (TPA) (means ± SD) of goat meat affected by moringa seed extract during different tenderization time.

Item	Control	Tenderization time (hr.)		
	0	2	24	46
Hardness (g)	4720.3^{a} ± 2354.2	303.0^{b} ± 140.8	447.8^{b} ± 272.6	2836.4^{ab} ± 3629.2
Chewiness (mJ)	1057.01^{a} ± 670.9	81.49^{b} ± 32.2	128.62^{b} ± 89.2	724.61^{ab} ± 1040.6
Firmness	3971.5^{b} ± 885.9	5350.1^{b} ± 2511.7	8883.3^{a} ± 3494.6	7105.3^{ab} ± 2980.9
Toughness	25448.6^{b} ± 5561.7	29762.8^{ab} ± 13967.5	44764.4^{a} ± 12936.3	36969.4^{ab} ± 13161.5
Adhesiveness	-47.17^{b} ± 30.3	-12.79^{a} ± 12.7	-24.29^{ab} ± 19.4	-22.74^{ab} ± 14.2
Gumminess (g)	1886.87^{a} ± 959.2	149.77^{b} ±70.0	201.89^{b} ± 122.7	1213.20^{ab} ± 1614.6
Cohesiveness	0.402^{b} ± 0.08	0.498^{a} ± 0.09	0.448^{ab} ± 0.02	0.425^{ab} ± 0.04
Springiness (mm)	0.541^{a} ± 0.14	0.563^{a} ± 0.08	0.626^{a} ± 0.08	0.573^{a} ± 0.09
Resilience	0.248^{a} ± 0.06	0.166^{b} ± 0.032	0.157^{b} ± 0.03	0.225^{a} ± 0.04

Different letters (a, b, c) in the row indicate significant differences between means (p 0.05).

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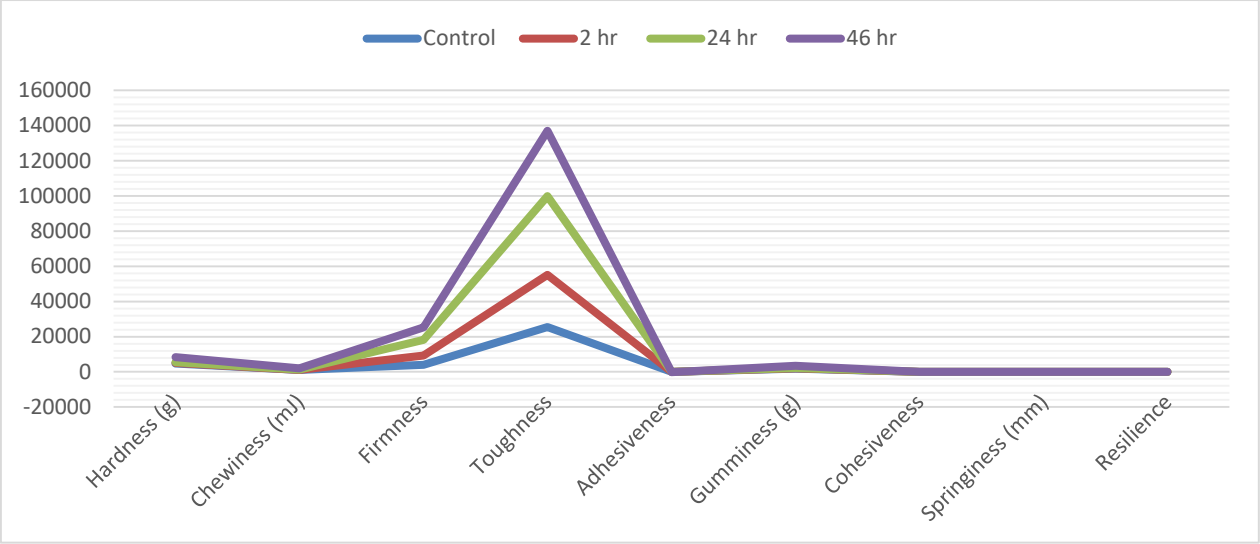

Fig 4. Texture profile analysis of goat meat affected by moringa seeds extract

3.3 Effects of Moringa Seed Extract on the Color of Goat Meat

Regarding lightness and yellowness, a significant difference was observed between the control and the other treatments, as all treated samples exhibited an increase in lightness and a decrease in yellowness compared to the control. There was a significant difference between the 2-hour treatment and the other (24, 46 hours) and the control in redness. The effect of redness was not substantial, with no difference between the control and 24- and 46-hour groups. However, the 2-hour group showed a significant difference compared to the control and the 24- and 46-hour groups.

Table 3. Color (means ± SD) of goat meat affected by moringa seeds extract during different tenderization time.

Item	**Control**	**Tenderization time (hr.)**		
	0	2	24	46
Color				
Lightness (L *)	44.5^{c} ± 2.7	57.3^{b} ± 2.7	65.2^{a} ± 2.5	64.5^{a} ± 1.5
Redness (a *)	6.8^{b} ± 1.2	9.1^{a} ± 1.4	7.3^{ab} ± 1.8	7.1^{ab} ± 2.1
Yellowness (b *)	12.3^{a} ± 1.6	2.4^{b} ± 0.7	1.3^{b} ± 1.1	1.5^{b} ± 0.6

The row's letters (a, b, c) indicate significant differences between means (P 0.05).

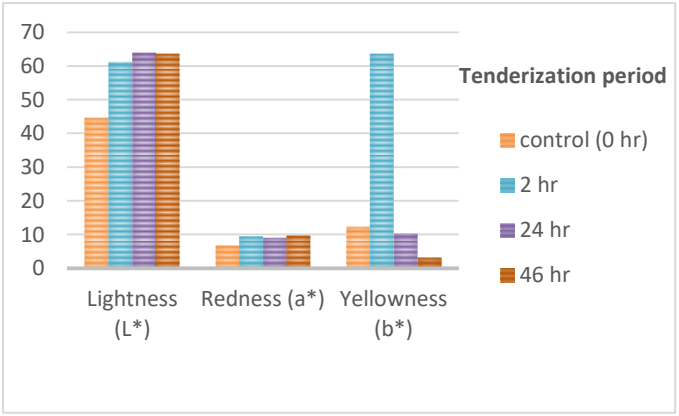

Fig 5. Color of goat meat affected by moringa seeds extract

4. DISCUSSION

4.1 Effects of Moringa Seed Extract on the pH and Cooking Loss of Goat Meat

Numerous studies have focused on Moringa seed extract regarding its effect on pH and cooking loss in goat meat, establishing that it has certain advantages in enhancing meat quality. The nutritional properties of Moringa oleifera have been proven to affect the physio-chemical properties of goat meat in terms of pH and cooking moisture loss. According to (Al-Juhaimi et al., 2016), the addition of Moringa seed flour slightly reduced the pH of raw patties with the storage time; this is not consistent with the current study, which indicates that the use of Moringa seed extract increased the PH with the storage time, but it was in the normal range that enhances meat tenderness without any adverse effect. Often, variation in pH among samples and the control shown in this study may be due to protein degradation caused by Moringa seed extract, which decreases the goat meat's ability to retain water, leading to a slight increase in pH. Moringa supplementation enhances the quality of goat meat, which is attributed to the increase in PH. Tender meat with a lower pH is more palatable and appealing to customers and consumers (Moyo et al., 2014). The dietary use of *Moringa* leaf in broiler chickens' diets increased pH values recorded post-slaughter, resulting in reduced cooking loss and improved water retention in meat, contributing to better texture and juiciness (Jiang et al., 2023).

This study showed significant differences in cooking loss among all treatments and controls. Based on the storage period, the increasing trend in cooking loss observed in this study may be attributed to denatured meat proteins resulting from using Moringa seed extract, which reduces the water-holding capacity. This process made the goat meat more tender. However, prolonged storage time leads to tough meat. This finding is consistent with the

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results reported by Rahman et al. (2020), who observed significant differences in the cooking loss of nugget samples across various storage treatments. Goats supplemented with Moringa leaf meal exhibited lower cooking losses of 25.4%, whereas those on a grass hay diet had 29.5% cooking losses (Moyo et al., 2014). A moringa-containing diet leads to improved moisture retention, which is crucial for maintaining the juiciness and quality of the meat (Sultana et al., 2018).

4.2 Effects of Moringa Seeds Extract on The Texture Profile Analysis of Goat Meat

Regarding tissue quality, Moringa extracts can enhance quality; however, excessive use may lead to an unappealing flavor and/or texture, lowering consumer acceptance. Therefore, finding the optimal amount of Moringa to minimize undesirable sensory characteristics in goat meat products is essential, as what happens in this study the seed extract was There was also a significant effect on the texture profile, where there was a decrease in hardness, chewiness, toughness, and firmness after two hours of marinating, which increased with increasing marinating time in 24, and 46 hours, this result was agreed with (Moyo et al., 2014), conducted the including Moringa leaf meal in goat diets showed lower Warner Bratzler shear force values which indicate tenderness of the meat increased, and the Goat meat infused with Moringa was rated higher in customer sensory results for features such as aroma and juiciness which indicates Moringa aids with improving texture as well as the quality of meat.

Moringa Oleifera extract decreased the hardness, gumminess, and chewiness of the chicken Meat Nuggets. Additionally, the addition of Moringa Oleifera extract did not alter the sensory attributes of the nuggets. The chicken Meat Nuggets remained stable and acceptable even on the 15th day of storage (Madane et al., 2019). Moringa oleifera leaf extract improved tenderness and juiciness in ground beef, suggesting its potential as a natural additive for enhancing the sensory attributes of meat (Abdallah et al., 2023). Mwankunda et al., (2023) the texture of ground beef significantly improved when treated with Moringa oleifera leaf extract (2%) compared to the control and the 0.5% treatment. Moringa-enriched products generally rely on sensory acceptability and maintain quality better over time than their non-enriched counterparts (Al-Juhaimi et al., 2016). The application of Moringa seeds in improving meat quality remains limited, with further research required to optimize inclusion levels, methods, and forms to achieve the expected benefits.

4.3 Effects of Moringa Seed Extract on the Color of Goat Meat

The effects of Moringa seeds on Goat meat color depend on the amount of Moringa used and the processing methods employed. In this study, using Moringa seed extract increased lightness (L *) in all treatment samples compared to the control. This finding is consistent with (Al-Juhaimi et al., 2016), who demonstrated that the use of Moringa seed flour in beef patties also increased lightness (L *); Moringa oleifera flour has a significant impact on the lightness of chicken meat, as A 3% inclusion level of Moringa flour increased lightness to 54.25% (Wulandari et al., 2024). It was documented that Moringa supplementation slightly influenced the lightness of broiler breast meat, with variation depending on the form and concentration used (Qwele et al., 2013).

Additionally, the current study found that the 2-hour group showed increased redness (a*) compared to the control and the 24- and 46-hour groups; this finding does not align with (Al-Juhaimi et al., 2016), who demonstrated that Moringa seed flour reduced the redness (a*) values, and also with Limbe et al., 2024, who reached A 2% concentration of Moringa leaf powder reduced the redness of broiler meat, perhaps owing to antioxidant action that would retard oxidative changes that would otherwise enhance redness. In contrast, another study reported no significant impact on redness with adding Moringa leaf meal, suggesting variation in experimental conditions or chicken lines (Vásquez et al., 2024).

There was even a difference in yellowness (b*) between the current study and some previous studies, as the current study found that using Moringa seed extract reduced yellowness (b*). In contrast, (Al-Juhaimi et al., 2016)A study found that adding Moringa seed flour to beef patties increased yellowness (b*). There have been no reported changes in yellowness in some studies using Moringa supplementation (Wulandari et al., 2024). Supplementing broiler diets with Moringa oleifera and fermented Moringa oleifera has been shown to enhance the lightness (L *), redness (a *), and yellowness (b *) values of the breast of broiler meat (Jiang et al., 2023). (Al-Harthi et al., 2023) revealed that Moringa peregrina seed meal, whether raw or autoclaved, significantly affected the broiler breast meat color parameters, specifically lightness (L*), redness (a*), and yellowness (b*).

While Moringa oleifera influences meat color, the findings are not uniform across all studies, including the current study. Experimental condition variations, such as the composition of the Moringa used (flour, leaf meal, or extract) and concentration, can yield different results. Additionally, the antioxidant activity of Moringa may be the reason for variations, which may alter the oxidative stability and appearance of meat. Further studies are needed to standardize these variables and elucidate the mechanisms underlying the effect of Moringa on meat color.

5. CONCLUSION

There is a growing interest in exploring natural alternatives, such as *Moringa* and other plants and fruits, for meat tenderization. Studies on *Moringa* have been limited, especially those focusing on Goat meat tenderization and meat quality, which are scarce. Most previous studies have focused on other types of meat, leaving a gap in understanding how Moringa impacts goat meat quality, particularly regarding tenderness. The present study reveals significant differences in pH between the control and treated samples, all of which fall within the normal range and promote tenderness without any adverse effects. Also, Moringa seed extract increased the cooking loss value in treated samples compared with the control. There was also a significant effect on the texture profile, where a decrease in hardness, chewiness, toughness, and firmness was observed after two hours of marinating, which increased with longer marinating times on the other treated samples. There were also changes in the color of goat meat attributed to the strong antioxidant effect of Moringa and the effect of the enzymes and active compounds it contains. The study suggested that a 2-hour treatment was the most effective option for continuous meat tenderization, opening up another avenue for further research into the optimal duration and amount required to tenderize meat without adverse effects.

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REFERENCES

1. **Abdallah, R., Mostafa, N. Y., Kirrella, G. A. K., Gaballah, I., Imre, K., Morar, A., Herman, V., Sallam, K. I., & Elshebrawy, H. A.** (2023). Antimicrobial Effect of Moringa oleifera Leaves Extract on Foodborne Pathogens in Ground Beef. *Foods*, *12*(4), 1–13. https://doi.org/10.3390/foods12040766
2. **Akib, M. G., Rifat, A., Bormon, C., Dutta, A., Ataher, M. S., Azzam, M., Farouk, M. H., Das, R., Azad, M. A. K., & Mahfuz, S.** (2024). Effects of Moringa oleifera Leaf Powder on the Growth Performance, Meat Quality, Blood Parameters, and Cecal Bacteria of Broilers. *Veterinary Sciences*, *11*(8). https://doi.org/10.3390/vetsci11080374
3. **Al-Harthi, M. A., Attia, Y. A., Elgandy, M. F., & Bovera, F.** (2023). The effects of Moringa peregrina seed meal, autoclaving, and/or exogenous enzyme cocktail on performance, carcass traits, meat quality, and blood lipids of broilers. *Frontiers in Veterinary Science*, *10*(July), 1–18. https://doi.org/10.3389/fvets.2023.1158468
4. **Al-Juhaimi, F., Ghafoor, K., Hawashin, M. D., Alsawmahi, O. N., & Babiker, E. E.** (2016). Effects of different levels of Moringa (Moringa oleifera) seed flour on quality attributes of beef burgers. *CYTA - Journal of Food*, *14*(1), 1–9. https://doi.org/10.1080/19476337.2015.1034784
5. **Das, A., Biswas, S., Nanda, P. K., Chatterjee, N., Pal, S., Dhar, P., Verma, A. K., Bhattacharya, D., Koshy, R., & Das, A. K.** (2024). Moringa pod-derived antioxidant dietary fibre as a quality enhancer in goat meat nuggets. *Sustainable Food Technology*, *2*(1), 232–242. https://doi.org/10.1039/d3fb00177f
6. **Dubeni, Z. B., Buwa-Komoreng, L. V., & Mthi, S.** (2024). *The Potential Application of Moringa oleifera Extracts as Natural Preservatives of Chicken Meat*. 1–12. https://doi.org/10.1177/09731296241288922
7. **Ezzat, G. A., Mohamed, M. A., Emara, M. M. T., Yassien, N. A., & Mansour, N. K. M**. (2020). Effect of Moringa oleifera aqueous extracts on the physicochemical characteristics, microbiological quality and biogenic amines of semi-dry fermented sausage. *International Journal of Veterinary Science*, *9*(2), 285–290. https://doi.org/10.37422/IJVS/20.019.
8. **Hafez, M., EL-Roos, N. A. A., & Elsabagh, R.** (2024). Impact of papain and bromelain fortification on chilled camel meat quality. *Benha Veterinary Medical Journal*, *39*, 140–144. https://bvmj.journals.ekb.eg/jufile?ar_sfile=322559
9. **Honikel, K. O**. (1998). Reference methods for the assessment of physical characteristics of meat. *Meat Science*, *49*(4), 447–457. https://doi.org/10.1016/S0309-1740(98)00034-5
10. **Jiang, X., Yang, J., Zhou, Z., Yu, L., Yu, L., He, J., Zhu, K., Luo, Y., Wang, H., Du, X., Huang, Q., Zhao, C., Liu, Y., & Fang, C**. (2023). Moringa oleifera leaf improves meat quality by modulating intestinal microbes in white feather broilers. *Food Chemistry: X*, *20*(June), 100938. https://doi.org/10.1016/j.fochx.2023.100938
11. **Madane, P., Das, A. K., Pateiro, M., Nanda, P. K., Bandyopadhyay, S., Jagtap, P., Barba, F. J., Shewalkar, A., Maity, B., & Lorenzo, J. M.** (2019). Drumstick (Moringa oleifera) flower as an antioxidant dietary fibre in chicken meat nuggets. *Foods*, *8*(8), 1–19. https://doi.org/10.3390/foods8080307
12. **Mohamed, T. H. A., Sumarmono, J., Fatoni, A., Frah, A. Z. A., Fadhlurrohman, I., & Yusuf, H. M.** (2025). Improving Goat Meat (Longissimus Muscle) Tenderization by Using Moringa Oleifera Leaves. *E3S Web of Conferences*, *609*. https://doi.org/10.1051/e3sconf/202560902007
13. **Mohd Azmi, S. I., Kumar, P., Sharma, N., Sazili, A. Q., Lee, S. J., & Ismail-Fitry, M. R.** (2023). Application of Plant Proteases in Meat Tenderization: Recent Trends and Future Prospects. *Foods*, *12*(6), 1–24. https://doi.org/10.3390/foods12061336
14. **Moyo, B., Masika, P., & Muchenje, V.** (2014). Effect of feeding Moringa (Moringa oleifera) leaf meal on the physico-chemical characteristics and sensory properties of goat meat. *South African Journal of Animal Science*, *44*(1), 64. https://doi.org/10.4314/sajas.v44i1.9
15. **Mwankunda, L. J., Nyamete, F., & Kilima, B**. (2023). Exploring the Influence of Moringa oleifera Leaves Extract on the Shelf Life of Ground Beef during Refrigerated Storage. *European Journal of Medicinal Plants*, *34*(10), 42–52. https://doi.org/10.9734/ejmp/2023/v34i101164
16. **Orynbekov, D., Amirkhanov, K., Kalibekkyzy, Z., Smolnikova, F., Assenova, B., Nurgazezova, A., Nurymkhan, G., Kassenov, A., Baytukenova, S., & Yessimbekov, Z.** (2024). Study on the Combined Effects of Bromelain (Ananas comosus) Enzyme Treatment and Bacteria Cultures on the Physicochemical Properties and Oxidative Stability of Horse Meat. *Processes*, *12*(8). https://doi.org/10.3390/pr12081766
17. **Qwele, Muchenje, Oyedemi, Moyo, & Masika.** (2013). Effect of dietary mixtures of moringa (Moringa oleifera) leaves, broiler finisher and crushed maize on anti-oxidative potential and physico-chemical characteristics of breast meat from broilers. *African Journal of Biotechnology*, *12*(3), 290–298. https://doi.org/10.5897/ajb12.115
18. **Rahman, M. H., Alam, M. S., Monir, M. M., & E Rahman, S. M.** (2020). Effect of Moringa oleifera leaf extract and synthetic antioxidant on quality and shelf-life of goat meat nuggets at frozen storage. *Ijfr*, *7*(October), 34–45.
19. **Sharma, P., Wichaphon, J., & Klangpetch, W.** (2020). Antimicrobial and antioxidant activities of defatted Moringa oleifera seed meal extract obtained by ultrasound-assisted extraction and application as a natural antimicrobial coating for raw chicken sausages. *International Journal of Food Microbiology*, *332*, 108770. https://doi.org/10.1016/j.ijfoodmicro.2020.108770
20. **Sultana, N., Razak Alimon, A., Huque, S., Sazili, A. Q., Yaakub, H., Mohammad, S., Hussain, J., & Das, N. G.** (2018). Study of Meat Quality of Goats Fed Rice Straw Supplemented with Moringa (Moringa oleifera Lam.) Foliage. *Asian Journal of Agriculture and Food Sciences*, *06*(01), 2321–1571. www.ajouronline.com
21. **Vásquez, J. V. A., Vaz, R. G. M. V., Machado, S. B., Rodrigues, K. F., Araújo, C. C., & Pinedo, W. C.**

DOI: 10.5281/zenodo.15572214

(2024). Moringa leaf meal in diets of slow-growing chickens on metabolizability, performance, carcass, organ biometry and meat colorimetry. *Revista Brasileira de Saude e Producao Animal*, *25*, 1–18. https://doi.org/10.1590/S1519-994020230035.

22. **Wulandari, Y. R., Nurhassarah, A. N., & Radiati, L. E.** (2024). The Effect of Moringa oleifera Flour Addition on The Quality of Chicken Meat Dimsum. *Jurnal Ilmu Dan Teknologi Hasil Ternak*, *19*(2), 78–91. https://doi.org/10.21776/ub.jitek.2024.019.02.2

DOI: 10.5281/zenodo.15572214