Effects of Cooking Methods on Meat Quality of West African Dwarf Rams Fed Napier Grass Silage, Ensiled Sorghum and Crop Residue

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ABSTRACT

Background and Objective: The West African Dwarf (WAD) sheep breed is valued for its adaptability and potential for meat production in smallholder farming systems. To enhance their economic value and meet consumer demands, optimizing growth performance and meat quality in WAD rams is crucial. This study examines the growth performance and meat quality of weaner WAD rams fed *Pennisetum purpureum* (Napier grass) silage supplemented with sorghum ensiled and crop residues. It assesses sensory evaluation and carcass characteristics to determine the impact of different cooking methods on meat quality. **Materials and Methods:** Forty WAD rams were randomly assigned to four dietary treatments: T1 (cassava peel plus urea, CSP+U), T2 (cassava peel plus broiler litter, CSP+BL), T3 (cassava peel plus Napier grass and sorghum ensiled, CSP+NSE) and T4 (cassava peel plus crop residues, CSP+CR), with ten replicates each. The rams were housed in ventilated pens and fed *ad libitum* for 90 days, with continuous access to fresh water. Daily feed intake and weekly weight measurements were recorded to monitor growth performance. Data were analyzed using one-way ANOVA, with differences compared using Duncan's Multiple Range Test at a significance level of $p < 0.05$. **Results:** Significant variations were found in sensory attributes such as color, flavor, tenderness and juiciness across cooking methods. Microwaving generally yielded higher sensory scores compared to boiling and oven drying, with the highest color and flavor scores in microwaved meat from rams fed CSP+BL. Boiling preserved tenderness and juiciness better than oven drying, with boiled meat from the CSP+NSE diet being the most desirable. **Conclusion:** This study highlights the importance of cooking methods in meat quality and consumer acceptability. The findings suggest that dietary supplementation and appropriate cooking methods can significantly enhance meat quality, supporting improved consumer satisfaction and potentially better market value for WAD ram meat.

INTRODUCTION

The West African Dwarf (WAD) sheep breed is known for its remarkable adaptability to various environmental conditions and its potential for meat production in smallholder farming systems. However,

despite its resilience, the optimization of growth performance and meat quality in WAD rams remains a critical area of focus to enhance their economic value and meet increasing consumer demands[1].

Feed plays a crucial role in determining the growth and meat quality of ruminants. *Pennisetum purpureum*, commonly known as Napier grass, is widely used in tropical regions due to its high productivity and nutritional value[2]. Supplementation with sorghum ensiled and crop residues can further enhance the nutritional profile of the diet, promoting optimal growth and development in WAD rams[3]. Given the increasing importance of sustainable and efficient animal production systems, improving the dietary management of these rams is essential for achieving superior meat quality. This study lies in the need to understand how different cooking methods interact with dietary regimes to influence meat quality. Cooking methods such as boiling, oven drying and microwaving are known to impact the sensory attributes of meat, including color, flavor, tenderness and juiciness[4].

Understanding these interactions can provide valuable insights for producers and consumers alike, ensuring that the meat not only meets nutritional standards but also satisfies consumer preferences[5]. Mercan *et al.*[6] has indicated that diet composition significantly affects meat quality in small ruminants. However, the specific impacts of combining Napier grass silage with sorghum ensiled and other crop residues, along with various cooking methods, have not been extensively studied in WAD rams. This gap in the literature underscores the importance of this research in contributing to the broader understanding of meat science and animal nutrition[6-8]. The objective of this study is to investigate the growth performance and meat quality of weaner WAD rams fed *Pennisetum purpureum* silage supplemented with sorghum ensiled and crop residues. The study will assess sensory evaluation and carcass characteristics to determine the impact of different cooking methods on meat quality. By elucidating the relationships between feeding regimes, cooking methods and meat attributes, this research aims to optimize meat production systems and enhance consumer satisfaction.

MATERIALS AND METHODS

Study area and study duration: The study was carried out at the Teaching and Research Farm of the Department of Animal Production and Health, Faculty of Agriculture, Federal University Oye-Ekiti, Ekiti State, Nigeria. The location is within Longitude $5.5145°E$ and Latitude $7.7983°N$ and at an elevation of 570 m above sea level. The climate of the study area is typically tropical with relative humidity ranging from 57-92% and mean average daily temperature of $68-90°F$.

This study was carried out over a period of three months, from June, 2020 to August, 2021.

Experimental design and sample size: This study was conducted at the Department of Animal Production and Health, Federal University Oye-Ekiti, Nigeria. The experimental animals consisted of forty Weaner West African Dwarf (WAD) rams, randomly assigned to four dietary treatments. Each treatment group contained ten rams. The diets included:

- **T1:** *Pennisetum purpureum* (Napier grass) silage supplemented with cassava peel plus urea (CSP+U)
- **T2:** *Pennisetum purpureum* silage supplemented with cassava peel plus broiler litter (CSP+BL)
- **T3:** *Pennisetum purpureum* silage supplemented with cassava peel plus Napier grass and sorghum ensiled (CSP+NSE)
- **T4:** *Pennisetum purpureum* silage supplemented with cassava peel plus crop residues (CSP+CR)

Feeding and management: The rams were housed in well-ventilated pens and each group was fed *ad libitum* with their respective diets for a period of 90 days. Fresh water was provided continuously.The feed intake was recorded daily and the animals were weighed weekly to monitor their growth performance.

Meat sample collection and preparation: At the end of the feeding trial, three rams from each treatment group were randomly selected for slaughter. The carcasses were processed following standard procedures. Meat samples were collected from the hind leg muscles of each carcass.

Cooking methods: The collected meat samples were subjected to three different cooking methods:

- **Boiling:** Meat samples were boiled in water at 100°C for 30 min
- **Oven drying:** Meat samples were oven-dried at 150°C for 60 min
- **Microwaving:** Meat samples were microwaved on high for 10 min

Sensory evaluation: Sensory evaluation was conducted by a panel of ten trained assessors using a 4-point hedonic scale where 4, 3 and 2 are very desirable, slightly acceptable and unacceptable, while 1 is very unacceptable. The sensory parameters evaluated included:

- Color
- Flavor
- Tenderness
- Juiciness
- Number of chews
- Remains after chewing

Statistical analysis: Data were analyzed using a one-way ANOVA to determine the effects of different cooking methods on the sensory parameters of meat from WAD rams. Differences between means were compared using Duncan's Multiple Range Test at a significance level of $p < 0.05$.

RESULTS

Sensory evaluation: The study evaluated the effects of different cooking methods and dietary treatments on the sensory properties of meat from West African Dwarf (WAD) rams. The sensory parameters assessed included color, flavor, tenderness, juiciness, number of chews and remains after chewing.

Boiling

Color: The boiled meat samples from the CSP+U and CSP+NSE diets both scored the highest in color (28), indicating a more desirable appearance compared to CSP+BL (22) and CSP+CR (24). This suggests that certain dietary supplements can enhance the visual appeal of boiled meat.

Flavor: Flavor scores for boiled meat did not show significant variation across treatments (24-25), suggesting that boiling tends to homogenize the flavor profile regardless of the dietary supplement used.

Tenderness and juiciness: The tenderness scores were highest for CSP+U and CSP+NSE diets (23-25), indicating that these supplements may contribute to a more tender meat texture. Juiciness followed a similar trend, with CSP+U, CSP+BL and CSP+NSE showing higher scores (24-25) compared to CSP+CR (21).

Number of chews and remains after chewing: The number of chews was lowest for CSP+NSE (204) and highest for CSP+CR (259), indicating that meat from CSP+NSE was more tender and easier to chew. Additionally, CSP+CR had the lowest remains after chewing (18), suggesting a less desirable texture despite fewer chews.

Oven drying

Color and flavor: Oven-dried meat showed lower color scores across all treatments, with CSP+U scoring the lowest (21). Flavor scores also remained relatively low and uniform (21-23), indicating that oven drying may diminish the visual and flavor appeal of meat regardless of the diet.

Tenderness and juiciness: Tenderness and juiciness scores were notably low for CSP+CR (16-17), suggesting that oven drying, combined with certain dietary supplements, results in tougher and less juicy meat.

Number of chews and remains after chewing: The number of chews required was highest for CSP+CR (376), while remains after chewing were highest for CSP+NSE (18). These results indicate a tougher texture for CSP CR meat, making it less palatable.

Microwaving

Color: Microwaved meat exhibited higher color scores, especially for CSP+U and CSP+BL (29), compared to CSP+CR (23). This suggests microwaving preserves the visual appeal of meat better than other methods.

Flavor: The highest flavor scores were observed for CSP+BL (31), while CSP+CR had the lowest (23). This indicates a significant impact of diet on flavor when meat is microwaved.

Tenderness and juiciness: Tenderness was highest for CSP+NSE (21), while juiciness was also high for CSP+NSE and CSP+U (23-22). This suggests that these diets produce more palatable meat when microwaved.

Number of chews and remains after chewing: The CSP+CR required the highest number of chews (309), indicating tougher meat. Remains after chewing were similar across treatments, indicating uniformity in texture among microwaved samples.

Overall acceptability: The overall acceptability ranked CSP+NSE boiled meat as the most desirable (125), followed by CSP+U boiled meat (124). The CSP+CR oven-dried meat ranked the lowest (93), indicating a preference for boiled and microwaved meat over oven-dried.

The Table 2 presents the sensory evaluation results of meat samples from West African Dwarf rams fed different diets and subjected to three cooking methods: boiling, oven drying and microwaving. The diets include cassava peel plus urea (CSP+U), cassava peel plus broiler litter (CSP+BL), cassava peel plus Napier grass and sorghum ensiled (CSP+NSE) and cassava peel plus crop residues (CSP+CR). The sensory parameters evaluated are color, flavor, tenderness, juiciness and remains after chewing, along with total scores and rankings.

Boiled meat

CSP+U: This diet scored high in color (28), flavor (25), tenderness (23) and juiciness (24), with a total score of 124, ranking 2nd overall. The high scores indicate that boiled meat from this diet is visually appealing, flavorful, tender and juicy.

CSP+BL: Scoring lower in color (22) but high in flavor (24), tenderness (24) and juiciness (25), the total score is 115, ranking 5th. While the color is less desirable, the other attributes are favorable.

CSP+NSE: This diet scored the highest overall (125), with top marks in color (28), flavor (24), tenderness (25) and juiciness (24). It is the most desirable for boiled meat.

CSP+CR: Scoring moderately across all parameters, with a total score of 112 and a 7th place ranking, indicating a less favorable sensory profile compared to other boiled meats.

Oven-dried meat
CSP+U: Low scores in color (21), flavor (22), tenderness (19) and juiciness (18) with a total score of 95, ranking 10th. Oven drying negatively impacts sensory qualities.

CSP+BL: Similar low scores in all parameters, with a total score of 93, ranking 11th, indicating poor acceptability.

CSP+NSE: Slightly better scores than CSP+U and CSP+BL but still low overall, with a total score of 101, ranking 9th.

CSP+CR: Scoring lowest overall, with similarly poor results across all parameters, totaling 93 and ranking 12th.

Microwaved meat
CSP+U: High scores in color (29), flavor (28) and juiciness (22), but lower in tenderness (16), with a total score of 114, ranking 6th.

CSP+BL: Highest flavor score (31) among all samples and high color (29) and tenderness (18), with a total score of 115, ranking 4th.

CSP+NSE: Strong performance across all parameters, especially tenderness (21) and juiciness (23), with a total score of 117, ranking 3rd.

CSP+CR: Lower scores in all parameters, particularly color (23) and tenderness (17), with a total score of 101, ranking 8th.

Overall insights
Boiling: Produces meat with generally higher sensory scores, particularly for CSP+NSE and CSP+U diets.

Oven drying: Results in lower sensory scores across all diets, indicating a less preferred method for preparing WAD ram meat.

Microwaving: Maintains good sensory qualities, especially for CSP+NSE and CSP+BL diets.

Table 1 and 2 present the combination of diet and cooking methods significantly impacts meat quality. Boiled meat, particularly from CSP+NSE and CSP+U diets, is the most desirable, while oven-dried meat is generally the least preferred. Microwaving offers a good balance, especially for CSP+NSE and CSP+BL diets, maintaining high sensory scores. These findings highlight the importance of optimizing both diet and cooking methods to enhance the sensory qualities and consumer acceptability of WAD ram meat.

Secondary findings
Growth performance: The growth performance of WAD rams, assessed through weight gain and feed conversion ratios, varied significantly across dietary treatments. Rams fed CSP+NSE exhibited the highest average daily weight gain, suggesting that the nutritional synergy between Napier grass silage and sorghum ensiled is beneficial for growth.

Carcass characteristics: Carcass analysis showed that CSP+NSE fed rams had higher dressing percentages and better meat-to-bone ratios, indicating superior meat yield and quality.

Table 1 and 2 revealed that dietary supplementation and cooking methods significantly affect the sensory properties and overall acceptability of meat from WAD rams. Boiling and microwaving preserved meat qualities better than oven drying, with the CSP+NSE diet consistently yielding the most favorable sensory attributes and overall acceptability. These findings suggest that optimizing both diet and cooking methods can enhance meat quality and consumer satisfaction.

Table 1: Effects of different cooking methods on the organoleptic or sensory parameters of meat from WAD rams

Cooking methods	Sensory parameters	T1 (CSP+U)	T2 (CSP+BL)	T3 (CSP+NSE)	T4 (CSP+CR)	SEM
Boiling	Colour	28[a]	22[d]	28[a]	24[c]	0.15
	Flavour	25[c]	24[c]	24[c]	24[c]	0.16
	Tenderness	23[a]	24[a]	25[a]	25[a]	0.19
	Juiciness	24[a]	25[a]	24[a]	21[c]	0.16
	Number of chews	221[d]	235[d]	204[e]	259[d]	4.52
	Remains after chewing	24[a]	20[b]	24[a]	18[c]	0.24
Oven drying	Colour	21[d]	22[d]	24[c]	23[c]	0.15
	Flavour	22[d]	21[d]	22[d]	23[d]	0.16
	Tenderness	19[c]	17[b]	19[b]	16[c]	0.19
	Juiciness	18[c]	18[c]	18[c]	16[d]	0.16
	Number of chews	352[a]	317[b]	315[b]	376[a]	4.52
	Remains after chewing	15[d]	15[d]	18[c]	14[d]	0.24
Microwaving	Colour	29[a]	29[a]	27[b]	23[c]	0.15
	Flavour	28[a]	31[a]	27[b]	23[d]	0.16
	Tenderness	16[b]	18[c]	21[b]	17[c]	0.19
	Juiciness	22[b]	19[c]	23[a]	19[b]	0.16
	Number of chews	297[c]	318[b]	284[c]	309[c]	4.52
	Remains after chewing	19[b]	18[c]	19[b]	19[b]	0.24

Means bearing different superscripts along the same row and column are significantly different ($p < 0.05$). CSP+U: Cassava peel plus urea, CSP+BL: Cassava peel plus broiler litter, CSP+NSE: Cassava peel plus Napier grass and sorghum ensiled and CSP+CR : Cassava peel plus crop residues

Table 2: Overall acceptability of goat meat based on different cooking methods by taste panelist

Meat samples and cooking methods	Colour	Flavour	Tenderness	Juiciness	Remains after chew	Total	Ranking (%)	Ranking
Boiled meat								
CSP+U	28	25	23	24	24	124	9.5	2
CSP+BL	22	24	24	25	20	115	8.81	5
CSP+NSE	28	24	25	24	24	125	9.58	1
CSP+CR	24	24	25	21	18	112	8.58	7
Oven-dried meat								
CSP+U	21	22	19	18	15	95	7.28	10
CSP+BL	22	21	17	18	15	93	7.13	11
CSP+NSE	24	22	19	18	18	101	7.74	9
CSP+CR	23	23	16	16	14	93	7.13	12
Microwaved meat								
CSP+U	29	28	16	22	19	114	8.74	6
CSP+BL	29	31	18	19	18	115	8.81	4
CSP+NSE	27	27	21	23	19	117	8.97	3
CSP+CR	23	23	17	19	19	101	7.74	8

Ranking; 1: Best---12: Least, Means bearing different superscripts along the same row and column are significantly different ($p < 0.05$), scale used by Panel; 4: Very desirable, 3: Slightly acceptable, 2: Unacceptable, 1: Very unacceptable, values and means of ten panelists. Where, CSP+U: Cassava peel plus urea, CSP+BL: Cassava peel plus broiler litter, CSP+NSE: Cassava peel plus Napier grass and sorghum ensile and CSP+CR: Cassava peel plus crop residues

DISCUSSION

This study investigated the impact of different dietary treatments and cooking methods on the sensory properties of meat from West African Dwarf (WAD) rams as revealed in Table 1 and 2. The findings indicated that the CSP+NSE diet, when paired with boiling or microwaving, produced meat with superior sensory attributes, including color, flavor, tenderness, juiciness and overall acceptability. These results highlight the significant role that both diet and cooking methods play in determining meat quality.

The findings of this study aligned with several previous publications that emphasize the influence of diet on meat quality. For instance, Mercan *et al.*[6] and Ofori *et al.*[9] noted that the inclusion of high-quality forage in the diet enhances meat tenderness and flavor, which corroborates the high sensory scores observed in the CSP+NSE diet group. Additionally, Ali *et al.*[10] reported that protein-rich diets improve meat juiciness and tenderness, supporting the results obtained from the CSP+U and CSP+BL diets. In terms of cooking methods, the study's findings were consistent with those of Olfaz *et al.*[5], who found that boiling and microwaving preserve meat juiciness and tenderness better than oven drying. Similarly, Hwang *et al.*[11] observed that boiling enhances meat flavor and texture, which aligned with the high sensory scores for boiled meat in this study. However, some studies presented contrasting results. For example, Kim *et al.*[12] and Webb *et al.*[13] suggested that oven drying could enhance certain sensory attributes like flavor intensity due to Maillard reactions. This contradiction may be due to variations in meat type, preparation techniques, or specific dietary treatments used in different studies.

One of the significant benefits of this study is the comprehensive evaluation of both dietary treatments and cooking methods, providing a holistic view of their combined effects on meat quality. This approach allows for practical recommendations that can be directly applied to improve meat production and consumer satisfaction. However, there are limitations to consider. The study was limited to WAD rams and the results may not be generalizable to other breeds or livestock types. Additionally, sensory evaluation, while valuable, is inherently subjective and can be influenced by panelists' preferences and biases.

The results of this study in Table 1 and 2 have practical implications for both livestock producers and consumers. By adopting optimal dietary strategies like the CSP+NSE diet and cooking methods such as boiling and microwaving, producers can enhance meat quality and meet consumer demands for tender, flavorful and juicy meat. These findings can also guide the development of feeding protocols and cooking guidelines that maximize meat quality.

Future research should explore the long-term effects of these dietary treatments on the overall health and productivity of WAD rams to ensure that the observed benefits are sustainable. Additionally, expanding the study to include other breeds and livestock types would provide more generalizable results. Investigating the biochemical mechanisms underlying the observed sensory improvements could also offer deeper insights into how diet and cooking methods affect meat quality.

CONCLUSION

The study demonstrates that both cooking methods and dietary supplements significantly impact the sensory qualities of WAD ram meat. Boiling and microwaving, particularly with CSP+NSE and CSP+U diets, produced the most desirable meat in terms of color, tenderness and juiciness. Conversely, oven drying and the CSP+CR diet resulted in less favorable sensory characteristics. These insights are crucial for optimizing meat quality through diet and cooking methods, thereby enhancing consumer satisfaction.

SIGNIFICANCE STATEMENT

This study investigates the impact of different cooking methods on the sensory attributes and overall acceptability of meat from West African Dwarf rams-fed diets supplemented with Napier grass silage. The

research provides valuable insights into optimizing cooking practices to enhance meat quality, suggesting that both dietary supplementation and appropriate cooking methods can significantly improve consumer satisfaction and market value for WAD ram meat.

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