

Comparative evaluation of nutrient profile of shoulder and thigh muscles obtained from West African Dwarf and Red Sokoto goats

Fakolade, P. O., Aluko, O. P., Atoyebi, G. O. and Adesina, S. A

Department of Animal Science, Osun State University,

College of Agriculture, Ejigbo campus, Osun State.



*Corresponding author: gbenga.atoyebi@pgc.uniosun.edu.ng; 07035100013

Abstract

Animal protein is an essential nutrient that must be incorporated into a human's diets. As animal food, goat meat, chevon, is reported to have a rich nutrient profile and serves as a healthier alternative in the human diet because of its low fat. The fat content and other nutrient profiles are dependent on the type of muscles that meat is obtained thereby affecting the choice and diet of the populace therefore, this study was designed to evaluate the proximate composition, physicochemical properties and palatability of shoulder and thigh muscles of WAD and Red Sokoto (RS) goat using a standard procedure in a completely randomized design. Twelve bucks of a year old comprising six WAD and six RS, were purchased and raised semi-intensively for 10 weeks. The bucks were slaughtered, scalded and cut along the prima to extract the thigh and shoulder muscles which were assessed in the laboratory for meat quality. Table 1 shows that thigh muscles contained a higher amount of crude protein (WAD – 22.40%; RS – 22.10%) than shoulders (WAD – 20.48%; RS – 20.19%), but with no significant ($P > 0.05$) difference between the two breeds. Ether extract was significantly higher in the shoulder muscles of RS (5.95%). Minerals were more concentrated in shoulder muscles, particularly iron (23.91 mg/100g in WAD; 23.03 mg/100g in RS) and phosphorus (282.08 mg/100g in WAD; 286.78 mg/100g in RS), except magnesium which was significantly higher in thigh muscles (88.02 mg/100g in WAD; 86.64 mg/100g in RS). Thigh muscles had the highest water-holding capacity (RS – 103.51%; WAD – 97.20%) with no significant difference compared with shoulders (RS – 73.29%; WAD – 63.98%). Thigh muscles (RS and WAD) were preferred by consumers when boiled and grilled, based on tenderness, juiciness, flavour, and overall acceptability. For breeds, RS performed better in proximate, physicochemical, and palatability evaluation.

Keywords: Red Sokoto, WAD, buck, breeds and thigh muscles, shoulder muscles.

Évaluation comparative du profil nutritionnel des muscles de l'épaule et de la cuisse obtenus chez les chèvres West African Dwarf et les chèvres Red Sokoto.

Résumé



Les protéines animales sont des nutriments essentiels qui doivent être incorporés dans l'alimentation humaine. Comme aliment d'origine animale, la viande de chèvre, le chevon, est réputée avoir un riche profil nutritionnel et constitue une alternative plus saine dans l'alimentation humaine en raison de sa faible teneur en matières grasses. La teneur en matières grasses et d'autres profils nutritionnels dépendent du type de muscles dont la viande est obtenue, affectant ainsi le choix et l'alimentation de la population. Par conséquent, cette étude a été conçue pour évaluer la composition proximale, les propriétés physico-chimiques et la palatabilité des muscles de l'épaule et de la cuisse des chèvres WAD et Red Sokoto (RS) en utilisant une procédure standard dans un dispositif complètement aléatoire. Douze boucs d'un an comprenant six WAD et six RS, ont été achetés et élevés de manière semi-intensive pendant 10 semaines. Les boucs ont été abattus, échaudés et découpés le long de la ligne primaire pour extraire les muscles de la cuisse et de l'épaule qui ont été évalués en laboratoire pour la qualité de la viande. Le tableau 1 montre que les muscles de la cuisse contenaient une quantité plus élevée de protéines brutes (WAD – 22,40 % ; RS – 22,10 %) que les épaules (WAD – 20,48 % ; RS – 20,19 %), mais sans différence significative ($P > 0,05$) entre les deux races. L'extrait éthéré était significativement plus élevé dans les muscles de l'épaule de RS (5,95 %). Les minéraux étaient plus concentrés dans les

muscles de l'épaule, particulièrement le fer (23,91 mg/100g chez WAD ; 23,03 mg/100g chez RS) et le phosphore (282,08 mg/100g chez WAD ; 286,78 mg/100g chez RS), sauf le magnésium qui était significativement plus élevé dans les muscles de la cuisse (88,02 mg/100g chez WAD ; 86,64 mg/100g chez RS). Les muscles de la cuisse avaient la capacité de rétention d'eau la plus élevée (RS – 103,51 % ; WAD – 97,20 %) sans différence significative par rapport aux épaules (RS – 73,29 % ; WAD – 63,98 %). Les muscles de la cuisse (RS et WAD) étaient préférés par les consommateurs lorsqu'ils étaient bouillis et grillés, sur la base de la tendreté, de la jutosité, de la saveur et de l'acceptabilité globale. Pour les races, la RS a obtenu de meilleurs résultats dans l'évaluation proximale, physico-chimique et de palatabilité.

Mots-clés : Red Sokoto, WAD, bouc, races et muscles de la cuisse, muscles de l'épaule.

Introduction

Small ruminant production is one of the most resourceful and rewardable agricultural ventures in the world (David *et al.*, 2020). The management system of small ruminant animals such as goats favours both the small hold and large scale because of their modest feed requirement, utilization of alternative feeds, efficient conversion of limited feeds, easy handling and ability to thrive under any climatic condition (Ajagbe *et al.*, 2020). Goat plays an important role in livelihood of the holders producing milk and meat for human consumption (Hyelda, 2017). Goat meat can be relied on as one of the sources of animal protein. Protein is an essential nutrient; its deficiency can cause many diseases and also results in malnutrition. The insufficient supply of animal protein can be associated to inadequate production of the most common meats such as beef, chicken, and turkey, therefore, necessitating the need to increase the supply of animal protein by improving the production of small ruminant production like goat. Red Sokoto breed of goat has been reported to produce two litters of kids annually and reaches reproductive age by six months and in addition to this, the breed is easier and more profitable to raise (Adu *et al.*, 2009); this implies that a shift from red meat to goat meat will solve the problem of insufficient supply of animal protein because of its high prolific potential. Ofori and Hagan, (2021) also stated that WAD goat is also a good source of animal protein and the breed is valued for its prolific breeding potential. The ability of WAD goat to thrive in any climate condition will enhance its

all-year-round availability in almost all regions of the world, therefore, proffering a solution to protein shortage. The ability to efficiently convert low-quality forages and agro-industrial by-products into flesh shows that goat is of great economic value (Aye and Adeogun, 2010). Generally, goat meat has a distinctive taste and a desired chemical composition (Ivanovic *et al.*, 2016). It was reported that goat meat is a healthier alternative in human's diet compared to other types of red meat (Ivanovic *et al.*, 2016). In addition, polyunsaturated fatty acids are observed to be prevalent in goat meat and any diet rich in unsaturated fatty acid correlates with reduction in the risk of stroke and coronary disease (Ivanovic *et al.*, 2016). Goat meat is a good source of essential amino acids such as lysine, methionine, phenylalanine, threonine, tryptophan and valine (Aberle *et al.*, 2001). Red Sokoto breeds of goat is reported to be rich in vitamin A (Adu *et al.*, 2009), the researcher suggested that, eating goat meat improves healthy vision, immune system, reproduction, and growth and development of the consumer. Goat meat is reported to helps the heart, lungs, and other organs to work properly (Anaeto *et al.*, 2010). Regardless of the nutritional value, goat meat is less consumed globally compared to beef (Madruga and Bressan, 2011). However, there is a need to stimulate consumer's interest in goat meat by delving into their nutritional profile which may adequately provide consumers the nutrient composition especially protein. Therefore, this study was conducted to compare the shoulder and thigh muscles of two breeds of goat (WAD and Red Sokoto). To enhance comprehension

of consumer acceptance and the nutritional value of goat meat, it is essential to analyze the variations in composition and quality among different muscles. Proximate composition (moisture, protein, fat, and ash) tells you about the basic nutrients in meat that affect both its nutritional value and how long it will last. Mineral analysis is important because minerals like iron, phosphorus, and magnesium are important for human health and can change depending on the type of muscle. Physicochemical parameters, such as water-holding capacity, cooking loss, thermal shortening, cold shortening, and thaw rigor, affect the yield, tenderness, and juiciness of meat, which are all important signs of quality. Sensory characteristics like flavor, tenderness, juiciness, color, and overall acceptability are direct indicators of what consumers like. By comparing these parameters between the thigh and shoulder muscles of West African Dwarf and Red Sokoto goats, we can learn a lot about the nutritional and eating qualities of the two muscles. This information can help both consumers and processors make smart choices.

Materials and methods

The study was carried out at Teaching and Research Farm, College of Agriculture, Osun State University. Twelve bucks of a year old each (6 WAD and 6 Red Sokoto) were purchased and raised semi-intensively for 10 weeks after two weeks of acclimatization. The goats were fed with elephant grass, cassava peel, cowpea chaff and concentrate with adequate water supply alongside with grazing on forage.

Proximate and Mineral Compositions

Proximate composition (Protein, Ether extract, Ash and Moisture) and mineral analysis (Magnesium, Phosphorus and Iron) evaluation were carried out according to Official Analytical Chemist (AOAC, 18TH Edition, 2005).

Physicochemical evaluation

The physicochemical parameters (water holding capacity WHC, cooking loss, thermal shortening, cold shortening and thaw rigour)

were accordingly evaluated using the standard procedure:

WHC determination

The WHC samples were determined by the press method as slightly modified by Suzuki *et al.* (1991). It was thus calculated:

$$WHC = 100 - (Aw - Am)/(Wm - Mo) \times 9.47$$

Where: Aw = Area of water released from meat samples (cm²);

Am = Area of meat samples (cm²)

Wm = Weight of meat samples (g);

Mo = Moisture content of meat samples;

9.47= constant factor

Cooking Loss

The samples of known weight were taken from the meat and cooked in a moist heat to an internal temperature of 72°C; it is calculated thus:

$$\text{Cooking Loss} = (Iwm - Wcm)/Iwm \times 100$$

Where: Iwm = Initial weight of meat

Wcm= weight of cooked meat

Thermal Shortening

The samples of known length were taken from the meat and cooked in a moist heat to an internal temperature of 75°C for 20 minutes; it is calculated thus:

$$\text{Thermal shortening} = (Ilm - Lbm)/Ilm \times 100$$

Where: Ilm = Initial length of meat

Lbm = Length of broiled meat

Cold Shortening

Meat samples of known length were stored in the refrigerator for 24 hours at 4°C; it is calculated thus:

$$\text{Cold Shortening} = (Ilm - Lfm)/Ilm \times 100$$

Where: Ilm = Initial length of meat

Lfm = length of frozen meat

Thaw rigour

Meat samples of known weight were stored in the refrigerator for 24 hours at 4°C; it is calculated thus:

$$\text{Thaw rigour} = (Iwm \ Wfm) / Iwm \times 100$$

Where: Iwm = Initial weight of meat

Wfm = Weight of frozen meat

Meat processing

The meat samples (1kg) were subjected to two cooking processes: boiling (indirect heat) and grilling (direct heat). The samples were cut into different steaks (50g) for boiling and grilling. The steaks were boiled at 100°C for 20 minutes while the grilled meat was done at 150°C for 15 minutes by placing the steaks directly on the grilling machine.

Palatability

Results and Discussion

Table 1: Proximate and mineral composition of thigh and shoulder muscles of a-year-old WAD and Red Sokoto

Parameters(% or g)	T(WAD)	T(RS)	S(WAD)	S(RS)	SEM
Crude Protein(%)	22.40 ^a	22.10 ^a	20.48 ^b	20.19 ^b	0.05
Ash (%)	1.67 ^a	1.35 ^c	1.59 ^b	1.38 ^c	0.02
Ether extract(%)	4.32 ^c	4.54 ^b	4.38 ^{bc}	5.95 ^a	0.16
Moisture Content (%)	71.97 ^a	72.04 ^a	71.37 ^b	71.08 ^b	0.22
Magnesium (mg/100g)	88.02 ^a	86.64 ^a	81.89 ^c	84.05 ^b	0.37
Iron (mg/100g)	21.62 ^b	21.74 ^b	23.91 ^a	23.03 ^a	0.28
Phosphorus (mg/100g)	278.67 ^b	255.36 ^c	282.08 ^a	286.78 ^a	1.35

^{abc} means in the same row with different superscripts are significantly (P<0.05) different

T(WAD) – Thigh (WAD), T(RS) – Thigh (Red Sokoto), S(WAD) – Shoulder (WAD) and S(RS) – Shoulder (Red Sokoto).

Table 1 shows that thigh muscles of WAD and RS are higher in protein with no significant difference (P>0.05). The result obtained for WAD and RS thighs (22.40 and 22.10g) agreed with the result of Eneji *et al.* (2015) on a WAD goat-fed cassava peel-based diet where he obtained a mean protein of 22.28%. The crude protein of shoulder muscle of WAD and RS ranged from 20.19 – 20.48% and this agreed with 20.32% obtained by Alamin *et al.* (2014) for goat meat irrespective of the breed. USDA (2001) in its nutrient database gave a standard value of 23.00g as the amount of protein that should be present in goat meat. The result obtained in this study, especially for the thigh muscles (22.10 and 22.40g) is close to the standard value of 23.00g. The experiment's findings demonstrate that the protein content of goat meat (22.10–22.40%) is similar to the amounts reported for lamb (24.00%), beef (25.00%), pork (25.00%), and chicken

A total number of 18 trained panelists ranging from 24 to 45 years were selected based on their past performance and samples were randomly allocated to them, a 9 hedonic scale was used and the treatments were replicated three times. The samples were blind coded and scored each for flavour, tenderness, juiciness, colour and overall acceptability (Fakolade *et al.*, 2018).

Statistical Analysis

All data were subjected to analysis of Variance and means were separated using Duncan's Multiple Random (DMR) Test. The cohort software (2016), computer packaged was used for all statistical analysis.

(25.00%) (USDA, 2001). Although this shows that goat meat can make a substantial contribution to the amount of protein in the diet, it is not possible to replace other meats with goat meat solely on the basis of protein content because other factors like consumer preference, mineral profile, and fat composition must also be taken into account. Part of the muscle consumed also affects the protein in meat. This study revealed that; protein is highly concentrated in the thigh muscles, it can therefore be predicted that, thigh muscles are more nutritious than shoulder muscles. The least ether extract is found in the thigh muscles of WAD and RS breed; this could be attributed to the locomotive function of the muscles in the leg which may likely reduce the amount of fat contained in the muscle. The fat content of 4.32 – 5.95% is within the range of 0.80 – 21. 24% obtained by Ivanovic *et al.*, (2016). Also, the thigh muscle is significantly higher in moisture

content than the shoulder muscle and this can be predicted to be a result of low ether extract. This prediction aligned with the report of William (2007) that, the higher the moisture content, the lower the ether extract. Water or moisture content is a key nutrient and aside from this, it is important in nutrition as it carries nutrients to muscle cells which implies that, the high moisture content in a muscle will result in an improved nutrient profile. However, consumers with a high preference for meat that comes from shoulder muscle will possibly consume high amounts of magnesium, iron and phosphorus. It was observed in Table 2 that, thigh muscles (RS and WAD) have the capacity to retain their water when processed or cooked. High moisture content influences the quality of

meat, especially the water-holding capacity and juiciness (Ivanovic *et al.*, 2016). The WHC influences the juiciness and tenderness of muscle when converted into meat (Listrat *et al.*, 2016). Thermal shortening, cooking loss, cold shortening and thaw rigour are the reactions of meat to temperature; the higher the values obtained for these reactions, the tougher the meat becomes. This effect was observed in shoulder muscles because it was significantly higher in thermal shortening, cooking loss, cold shortening and thaw rigour. Drummond *et al.* (2005) reported that cold shortening and thermal shortening are capable of reducing the quality of meat as a result of toughness as observed in the shoulder muscles.

Table 2: Physicochemical properties of thigh and shoulder muscles of WAD and Red Sokoto

Parameter (%)	T(WAD)	T(RS)	S(WAD)	S(RS)	SEM
Thermal Shortening	34.44 ^b	32.44 ^b	41.26 ^a	40.09 ^a	2.05
Cooking loss	72.06 ^b	71.44 ^c	75.21 ^a	72.61 ^b	0.96
Cold Shortening	13.96 ^b	11.21 ^b	20.78 ^a	18.96 ^a	2.71
Thaw Rigor	42.87 ^b	39.90 ^b	50.93 ^a	48.87 ^a	2.05
Water-Holding Capacity	97.20 ^a	103.51 ^a	63.98 ^b	73.29 ^b	9.94

^{ab} means in the same row with different superscripts are significantly ($P < 0.05$) different

T(WAD) – Thigh (WAD), T(RS) – Thigh (Red Sokoto), S(WAD) – Shoulder (WAD) and S(RS) – Shoulder (Red Sokoto).

Table 2 shows that physicochemical properties of thigh and shoulder muscles in West African Dwarf (WAD) and Red Sokoto (RS) goats were significantly different based on muscle type, with modest variations attributed to breed. Shoulder muscles in both breeds exhibited higher thermal shortening, cooking loss, cold shortening, and thaw rigor, indicating a greater tendency toward contraction and moisture loss during processing. These observations align with the findings of Zhang *et al.* (2022), who noted similar trends in the contraction behavior of more active muscles during heating and chilling.

In contrast, thigh muscles demonstrated significantly higher water-holding capacity, a key attribute that enhances juiciness and reduces drip loss in meat. Okeudo and Moss (2020) emphasized that higher water-holding capacity improves meat palatability, especially in tropical goat breeds. The superior WHC in

thigh muscles may be linked to a higher proportion of oxidative fibers, which are more stable during post-mortem changes.

The greater cooking loss in shoulder muscles, particularly in WAD goats, suggests a higher level of fluid and nutrient loss during thermal processing, which is consistent with results reported by Qamar *et al.* (2019), who attributed such loss to weaker water-binding structures in certain muscle types. Meanwhile, RS goats displayed slightly lower cold shortening and thaw rigor values than WAD, which may reflect genetic or physiological differences in muscle metabolism and post-mortem response (Ijaz *et al.*, 2021).

These findings highlight the need to consider both muscle type and breed when assessing meat quality and choosing processing strategies. Tailored approaches—such as modified chilling for shoulder muscles and optimized cooking methods—could help

reduce quality losses and maximize the value of meat from Indigenous breeds.

Table 3: Palatability status of boiled and grilled goat meat

Cooking Method	Parameters	T(WAD)	T(RS)	S(WAD)	S(RS)	SEM
BOILED	Colour	4.80 ^b	5.60 ^a	4.80 ^b	4.80 ^b	0.44
	Flavour	3.80 ^b	4.60 ^a	3.90 ^b	4.20 ^a	0.55
	Tenderness	5.60 ^b	6.10 ^a	5.30 ^b	5.90 ^a	0.19
	Juiciness	5.00 ^b	6.10 ^a	5.10 ^b	5.60 ^a	0.42
	Texture	5.90 ^a	6.10 ^a	5.10 ^b	5.20 ^b	0.15
	Acceptability	6.27 ^a	6.60 ^a	5.70 ^c	6.01 ^b	0.15
GRILLED	Colour	4.80 ^a	2.90 ^b	2.90 ^b	2.80 ^b	0.61
	Flavour	3.80 ^b	6.23 ^a	5.34 ^a	5.77 ^a	0.91
	Tenderness	5.60 ^a	4.32 ^a	4.40 ^a	4.50 ^a	2.39
	Juiciness	5.00 ^a	5.10 ^a	3.70 ^a	4.60 ^a	1.48
	Texture	5.90 ^a	4.50 ^a	4.13 ^a	4.40 ^a	2.19
	Acceptability	6.10 ^a	6.40 ^a	5.40 ^c	5.97 ^b	0.74

^{ab} means in the same row with different superscripts are significantly ($P < 0.05$) different

T(WAD) – Thigh (WAD), T(RS) – Thigh (Red Sokoto), S(WAD) – Shoulder (WAD) and S(RS) – Shoulder (Red Sokoto).

From Table 3, it can be said that methods of processing affect quality characteristics of meat like tenderness, juiciness, flavour and palatability by causing physical and biochemical changes in protein, carbohydrate, lipid and other minor components (Lee *et al.*, 2014). Muscle type and methods of meat processing have significant ($P < 0.05$) effects on the sensorial acceptance of goat meat. Thigh muscles gained the highest level of acceptance when boiled and grilled; this could be attributed to high WHC which probably influenced the tenderness, juiciness and texture of the meat. Consumers accepted shoulder muscle of Red Sokoto (RS) than that of WAD which could be a result of the high fat content (5.95%) recorded for RS shoulder which is capable of increasing the juiciness of the meat as a result of marbling fat and WHC. For the method of processing, it was revealed that boiled meat was preferred to grilled meat probably because grilled goat meat was exposed to direct heat at a temperature higher than that of boiled meat, this could be the reason for the meat toughening recorded in grilled meat because of the high amount of water lost in the grilling process. Drummond *et al.*, (2005) emphasized that, the higher the temperature, the tougher the meat because of the high degree of water loss.

Conclusion and Recommendation

According to this study, the thigh muscles of both Red Sokoto and West African dwarf goats had higher levels of crude protein, moisture, and water-holding capacity than the shoulder muscles. This made the thigh muscles more palatable to consumers and more nutritious. Although the shoulder muscles displayed higher cooking and thermal losses that adversely affected tenderness, they were richer in minerals like iron and phosphorus. Red Sokoto goats outperformed West African dwarf goats in terms of proximate composition, physicochemical stability, and sensory qualities, demonstrating that breed and muscle type have a major impact on goat meat quality. These results suggest that increasing consumer awareness of the nutritional and sensory benefits of goat meat, especially the thigh muscles, is necessary. To reduce quality losses, processing techniques that maintain tenderness and juiciness, like moist-heat cooking for shoulder muscles, should be promoted. In addition to keeping West African dwarf goats for their versatility and accessibility, farmers are encouraged to invest more in Red Sokoto goats due to their superior meat quality. Furthermore, expanding goat production systems as a sustainable strategy to increase animal protein supply and reduce protein

malnutrition requires policy support from stakeholders and the government.

References

- Aberle, E. D., Forrest J. C., Gerrard D. E., and Mills E. W. (2001).** Principles of Meat Science. 4th Edition. *Kendall and Hunt Publishing Co., Iowa, USA*. Chap. 12, Pp. 233- 246
- Adu, I. F., Buvanendran and Lakpini, C. A. M. (2009).** The reproductive performance of Red Sokoto goats in Nigeria. *The Journal of Agricultural Science*. Cambridge University Press. Vol. 93 (3) 563-566
- Ajagbe, A., Osigbodi, O., Aribido, S and Amina, O. (2020)** Nutrient intake of West African dwarf (WAD) goats fed cassava peels supplemented with nitrogen sources. *GSC Biological and Pharmaceutical Sciences*. 12. 189-195.
- Alamin S. A., Ahmed D. A., Ahmed H. E. (2014).** A comparative study on the chemical composition and cholesterol content of fresh camel, beef and goat meat. *Sudan Journal of Science and Technology*. Vol. 15(2) Pp. 73 – 80
- Anaeto, M., Adeyeye, J. A., Chioma, G. O., Olarinmoye, A. O., and Tayo, G. O. (2010).** Goat products: Meeting the challenges of human health and nutrition. *Agriculture and Biology Journal of North America*, 1(6), 1231-1236.
- Association of Analyst Chemists (AOAC) (2005).** Official Methods of Analysis 2005 Association of Analyst Chemists, 19th Edition, AOAC International, Inc. Washington DC.2005;1219
- Aye, P. A. S. and Adegun, M. K. (2010).** Digestibility and growth in West African Dwarf Sheep fed Gliricidia based multinutrient block supplements. *Agricultural and Biology Journal of North America* 1(6) Pp. 1133-1139.
- David, A. A., Osigbodi, O. B., Oluwatoyin, A. S., and Amina, O. (2020).** Nutrient intake of West African dwarf (WAD) goats fed cassava peels supplemented with nitrogen sources. *GSC Biological and Pharmaceutical Sciences*, 12(1), 189-195.
- Drummond L. S. and Sun D. W (2005).** Feasibility of water immersion cooking beef joints: Effects on product and yield. *Journal of Food Engineering*. Vol. 77(2). Pp. 289 – 294.
- Eneji C. A., Kalio G. A and Kennedy – Oko O. (2015).** Carcass composition of WAD Goats fed cassava peel-based diets. *Journal of Food Research*, Vol. 4 (1). Pp. 168 – 173.
- Fakolade P. O., Aluko O. P. and Omiwole J. O. (2018).** Evaluation of thigh muscles of 3 breeds of Cattle (White Fulani, Sokoto Gudali and Red Bororo). *African Journal of Food Science*. Vol. 12(7) Pp. 175 – 179.
- Hyelda, A., Yahya, M., Abakura, J., and Wafar, R. (2017).** Haematological and biochemical parameters of Red Sokoto Goats fed desert date (*Balanites aegyptiaca*) leaves as supplement to urea treated maize stover. *Journal of Advances in Biology and Biotechnology*, Vol. 15. Pp. 1-7. 10.9734/JABB/2017/36689
- Ijaz, A., Khan, M. A., Shahid, M., and Khan, M. Z. (2021).** Physiological and biochemical evaluation of goat meat quality. *Livestock Science*, 246, 104388.
- Ivanovic S., Pavlovic, I and Pisinov, B. (2016).** The quality of goat meat and its impact on human health. *Journal of Biotechnology in Animal Husbandry* Vol.32. Pp. 111-122.
- Lee, Y., Xiong, R., Chang, Y. H., Owens, C. M., and Meullenet, J. F. (2014).** Effects of cooking methods on textural properties and water-holding capacity of broiler breast meat deboned at various postmortem times. *Journal of Texture Studies*. Vol. 45 (5), 377-386.
- Listrat, A., Lebret, B., Louveau, I., Astruc, T., Bonnet, M., Lefaucheur, L., and Bugeon, J. (2016).** How muscle structure

and composition influence meat and flesh quality. *The scientific world journal*, 2016(1), 3182746.

- Madruza M. S., and Bressan M. C. (2011).** Goat meats: Description, rational use, certification, processing and technical developments. *Small Ruminant Research – SMALL RUMINANT RES.* Vol (98) Pp. 39 – 45
- Ofori, S. A. and Hagan, J. K. (2021).** Characteristics and trait preferences of West African Dwarf goat keepers in Ghana. *Tropical Animal Health Prod.* Vol 53 (3). Pp. 356.
- Okeudo, N. J., and Moss, B. W. (2020).** Effect of genotype on meat quality characteristics in goats. *Tropical Animal Health and Production*, 52(3), 997–1004.
- Qamar, A., Rehman, Z., Sattar, A., and Ahmad, M. (2019).** Impact of muscle type and post-mortem handling on meat quality. *Journal of Food Science and Technology*, 56(1), 145–154.
- Suzuki A., Kaima N. and Ikeuchi, Y. (1991).** Carcass composition and meat quality of Chinese purebred and European X Chinese crossbred pigs. *Meat Science* 29. Pp 31-41
- USDA (2001).** Nutrient database for standard reference, release 14. *U. S. Government Printing Office*, Washington D. C.
- Williams P. G. (2007).** Research online: Nutritional composition of red meat. *Faculty of Science, Medicine and Health*, University of Wollongong.
- Zhang, M., Chen, X., Liu, Y., Wang, J., and Zhao, L. (2022).** Comparison of meat quality traits in indigenous and commercial goat breeds. *Meat Science*, 185, 108712.
- Date received: 23rd June, 2025**
Date accepted: 26th August, 2025