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Factors Affecting Milk Yield and Milk Chemical Compositions in Nigerian Indigenous Goat Breeds

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Abstract

The present study examined the milk yield and chemical composition of three distinct Nigerian indigenous goat breeds. Specifically, the study utilized three breeds of indigenous goats, namely the Red Sokoto, Sahel, and West African Dwarf (WAD), with each breed being represented by five (5) does. The milking process involved hand stripping each doe in the morning for a period of 2-3 minutes, with milk yield being immediately weighed. The milk samples were transferred to the laboratory and kept at -20

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^{0}C for further proximate chemical analysis for crude protein, ash, and solid fat. The results indicated that Red Sokoto does produced the highest quantity of milk in comparison to Sahel and WAD does, although this was not statistically significant ($p<0.05$). Moreover, milk yield decreased significantly ($p<0.05$) with increased lactation weeks in all three breeds. However, milk yield was observed to increase with a higher number of kids per dams, which was statistically significant ($p<0.05$). The ash content of Red Sokoto goats' milk had the highest value with 0.93% as compared to the other two breeds. The WAD showed significantly higher fat content (4.20%) in comparison to Sahel (3.22%) and Red Sokoto goats (3.05%). The Red Sokoto goats had the highest solid non-fat (13.93%) as compared to the WAD and Sahel breeds with 3.66% and 12.9% respectively. In general, the Red Sokoto goats had the highest overall total solid in milk composition, with a value of 17.22% when compared to WAD and Sahel dams having 16.09% and 15.70%, respectively. Furthermore, the WAD breed had the highest crude protein content at 4.62%, while Red Sokoto and Sahel breeds had 4.43% and 4.04%, respectively. Overall, the findings of this study suggest that milk compositions varied across these goat breeds and that milk yield was affected by the breed, lactation week, and the number of kids per dam.

Keywords: Milk yield, milk composition, Red Sokoto, Sahel, West African dwarf

INTRODUCTION

Goats are commonly known as the "poor man's cow" due to their ability to provide ample milk for household consumption (Odunsi *et al.*, 2005). There are various production systems utilized in the dairy goat industry, including intensive and extensive methods. The extensive system is utilized by a diverse group of individuals, including pastoralists, smallholders, and those residing in marginal areas where goat milk serves as the sole source of protein and livelihood (Devendra, 2013). In 2010, India, Bangladesh, Sudan, Pakistan, France, and Spain combined to produce 62.2% of the world's goat milk (FAOSTAT, 2012). Developed and developing countries accounted for 30.9% and 19.1% of the total goat population, respectively (Olivier *et al.,* 2005). Goat milk is a crucial source of basic and essential nutrients, and its composition plays a pivotal role in the maintenance of human health. Despite similarities in composition with other types of milk, the unique characteristics of goat milk have made it a preferred choice for manufacturers catering to market and medical needs (Nayik *et al.*, 2021). Compared to cow milk, goat milk is more easily digested and has fewer allergic properties (Baenyi *et al.,* 2021).

Extensive research has been conducted on the lipid and fatty acid composition of goat milk, which is considered as its primary nutritional advantage over cow milk. The fat globules in goat milk are abundant in sizes less than 3.5 µm, whereas those in cow milk are typically 4.55 µm (Haenlein, 2003). Study conducted by Gallier *et al.* (2020) have reported that the number of fat globules smaller than 5 µm in goat milk is approximately 80%, compared to 60% in cow milk. This characteristic contributes to the softer texture of goat milk products and enhances lipid metabolism, thus making them more easily digestible (Goswami *et al.,* 2017). The fat in goat milk contains a higher proportion of medium-chain fatty acids and conjugated linoleic acid, which are associated with cheese flavor and the "goaty" odor of goat milk, as well as anti-carcinogenic and anti-atherogenic effects (Abbas *et al.,* 2014). In addition to fat, goat milk protein has greater buffering capacity and distinct alkalinity, which could be beneficial for the treatment of stomach ulcers due to higher levels of major buffering components such as proteins, non-protein nitrogen, and phosphate (Park, 2017). Casein micelles are another unique characteristic of goat milk (Prosser, 2021). They are less solvated, less heat stable, and lose β-casein more easily than cow milk, playing an important role in the cheese-making process, especially during renneting (Goswami *et al.*, 2017).

Milk quality depends on various factors, including breed, age, body size and weight, udder size, diet, stage of lactation, season, length of the dry period, and environmental temperature (Mestawet *et al.,* 2012). British Alpine, Saanen and Toggenburg are among the major dairy goat breeds in the United States, and they are famous for their high milk productivity (Mohsin *et al.,* 2019). In normal circumstances, goat breeder will choose the animal breed according to yield and productivity, while food manufacturers will favor milk with high functional properties (Park, 2017).

In recent years, there has been a surge in research focused on dairy goats, and it has become evident that dairy goat production has immense potential in the developing world (Luo, 2019). A related work on chemical and mineral composition of milk has been reported in varieties of goat breeds (British Alpine, Jamnapari, Saanen, Shami, and Toggenburg) in Malaysia (Mohsin *et al.,* 2019). Therefore, the objective of the study was to examine milk yield and chemical composition of goat milk, specifically protein, fat, moisture, and ash in three indigenous breeds of goats in Nigeria. The milk samples' chemical compositions were anticipated to differ significantly as it has been reported by Croissant *et al.* (2007) that breed constitutes a crucial factor in determining milk composition. The findings recorded in this study would be of great significance to goat breeders and manufacturers of goat milk products, as they can use them to enhance breed selection and cross-breeding programs, as well as design nutritionally enriched functional food products.

MATERIALS AND METHODS

Experimental Animals and Study Area

The study was conducted on Red Sokoto, Sahel, and West African Dwarf (WAD) goats at the Small Ruminant Research Farms of the National Animal Production Research Institute (NAPRI), Shika, ABU, Zaria. The age range of the goats utilized was between 8 and 12 months, as indicated by the farm records, which were subsequently substantiated through dental examination. Upon successful copulation, pregnancy was established, and the gravid goats were relocated to a different locale where they were allowed to acclimate. After parturition, each breed was represented by five (5) female goats. The experimental female goats were in the lactation stage. The female goats were semi-intensively managed and given *ad libitum* access to hay grasses (*Digitaria simutsi, Brachairia residensis* and *Brachairia decumbensis*) grown within the study area. Furthermore, the animals were provided with a concentrate mixture consisting of maize, maize offal, groundnut cake, bones, salt, cottonseed cake, and wheat offal grower mash as a supplement.

Sample Collection and Determination of Milk Yield

Fresh milk samples were acquired from three distinct breeds through manual milking. Collection was conducted weekly, early in the morning, over a twelve-week period. The samples were collected aseptically using sterile glass sample bottles and weighed using a handheld digital weighing scale (Hochoice Sensitive Electronic Balance, manufactured in Shanghai, China). The samples were then transported to the Biochemistry and Nutrition Laboratory at the National Veterinary Research Institute (NVRI), located in Shika, Ahmadu Bello University (ABU) Zaria, in an icebox maintained at 2 – 4 ^{0}C. The milk samples were subsequently preserved at – 20 ^{0}C until necessary for further use.

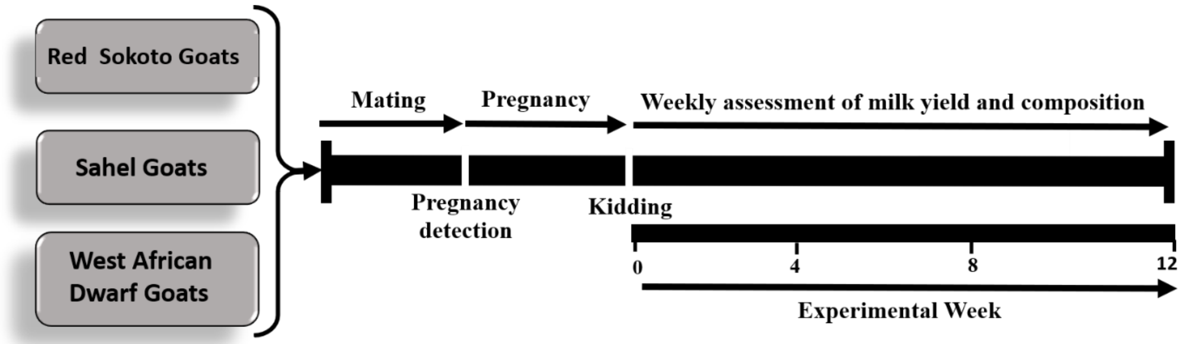

Figure 1: Schematic representation of the main experimental activities during the study

Proximate Analyses
The analyses of proximate was carried out on basic composition of the collected milk samples. All methods applied were based on the recommendations of the Association of Official Analytical Chemists (AOAC) International (2012).

Ash and moisture analysis
The percentage ash was determined using 2 g of sample in a crucible and subjected the sample to a high-temperature furnace at 550 ^{0}C for 60 min (AOAC International, 2012) as described by Zhang *et al.,* (2017). Prior to the ashing procedures, samples were dried in an oven at 100 ^{0}C for 60 minutes to remove moisture and avoid splatter. Moisture analysis was performed using 2 g of sample and processed according to AOAC International (2012) method 990.19 at 101 ^{0}C for 60 minutes.

Crude protein
The protein content (%) was determined according to the Kjeldahl method (method 991.20; AOAC International, 2012) as described by DeVriesa *et al.,* (2017). This was achieved by first digesting the milk sample in concentrated sulfuric acid in order to convert the total organic nitrogen to ammonium sulphate. Ammonia was formed and distilled into boric acid solution under an alkaline condition. The borate anions formed were titrated with standardized hydrochloric acid (HCl), hence nitrogen content representing the amount of crude protein was presented in percentage. Most proteins contain 16% of nitrogen, hence the conversion factor was 6.25 (Yu *et al.,* 2021).

Total fat
The total fat content was determined according Gerber method in line with ISO 2446 (Khaskheli *et al.,* 2005). It was done by first of all separating fat from proteins through the addition of sulfuric acid. The separation was facilitated using amyl alcohol and centrifugation. The fat content was read directly through a special calibrated butyrometer.

Statistical Analysis
Data were analyzed using analysis of variance (Proc ANOVA), and the significant differences among the means were tested using Tukey's test. The SAS software (Version 9.4) was used for these purposes.

RESULTS

Effect of Breeds on Milk Yield of Nigerian Indigenous Goats
In this study, it was found that there was no significant ($P<0.05$) variation in milk yield among the three indigenous goat breeds (Figure 2). Nonetheless, when comparing the breeds, it was

observed that Red Sokoto goats produced the highest volume of milk, with an average of 32.09 kg, compared to Sahel and WAD goats, which produced 31.83 kg and 31.12 kg, respectively.

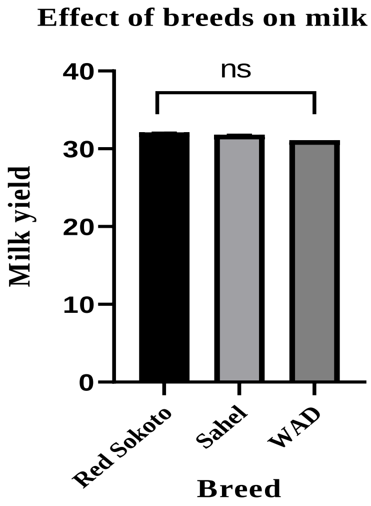

Figure 2: Bar diagrams showing effect of breeds on milk yield

Effect of Lactation Week Progression on Milk Yield

Table 1 revealed a marked dissimilarity (P<0.05) in the quantity of milk produced during various weeks of lactation. It was observed that the volume of milk produced decreased as lactation progressed. This finding suggests that goats are capable of generating a larger volume of milk during the kidding week, which subsequently declines until the drying up stage.

Table 1: Milk yield produced per week during lactation in goats

Week in Lactation	Milk Yield
1	46.46^{a}
2	42.55^{ab}
3	38.45^{abc}
4	35.51^{abcd}
5	32.98^{cde}
6	29.32^{cde}
7	28.97^{cde}
8	28.42^{cde}
9	25.76^{de}
10	24.52^{de}
11	23.75^{e}
12	23.41^{e}
SEM	0.760
LOS	**

SEM = Standard error of mean; LOS = level of significant;

Effect of Number of Kids per Dam on Milk Yield

The effect of number of kids on dam milk yield showed significant (P<0.05) differences in all the breeds (Figure 3). Milk yield was shown to increase with the number of kids per dam. Dams suckled by three kids (44.55 kg) gave more milk than those with twin kids (32.48 kg).

Similarly, dams with two kids gave more milk than those with one kid (29.10 kg). However, the differences in the quantity of their milk yields were not statistically significant.

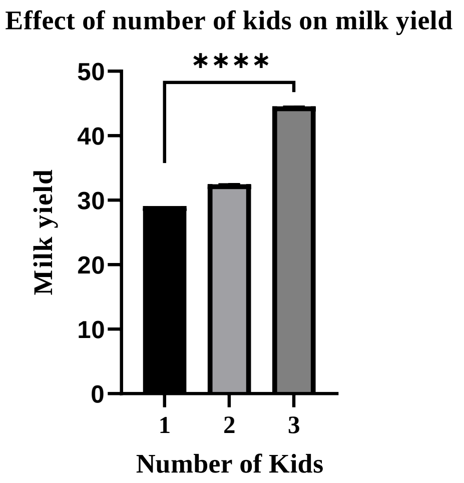

Figure 3: Effect of number of kids on milk yield during lactation in three Nigerian indigenous goats.

Chemical Composition of Milk in the Three Breeds

The chemical composition of milk from Nigerian indigenous goats is subject to variation, as depicted in Table 4. Notably, the ash content of milk from the Red Sokoto breed was observed to have the highest value at 0.93%, as compared to the other two breeds. Additionally, the WAD exhibited numerically higher fat content at 4.20%, in comparison to Sahel (3.22%) and Red Sokoto (3.05%). The Red Sokoto goat was found to have the highest solid non-fat content at 13.93%, as compared to the WAD and Sahelian goats with 3.66% and 12.9%, respectively. In terms of overall total solid content, the Red Sokoto goats had the highest value at 17.22%, as compared to WAD and Sahelian breeds with 16.09% and 15.70%, respectively. Crude protein content was also assessed, with the WAD exhibiting 4.62%, while Red Sokoto and Sahelian breeds had 4.43% and 4.04%, respectively.

Table 4: Mean chemical composition of milk according to goat breeds

Breed	Crude protein (%)	Solid non-fat (%)	Fat (%)	Total solid (%)	Ash (%)
Red Sokoto	4.433	13.93	3.050	17.22	0.9275
Sahel	4.043	12.90	3.225	15.70	0.8675
WAD	4.618	13.66	4.250	16.09	0.9000

DISCUSSION

The findings of our study revealed that Red Sokoto goats produced a greater quantity of milk in comparison to Sahel and West African dwarf goats. These results are consistent with previous studies conducted by Makun *et al.* (2008); Makun *et al*. (2013) which observed that Red Sokoto goats produced more milk than Sahelian goats fed with concentrate supplements. The observed differences in milk production between breeds may be attributed to variations in genetic potential, as reported by Kendall *et al.* (2009).

Research conducted by Idowu and Adewumi (2017) further supports the notion that dairy goat breeds have a significant effect on milk yield. Guney *et al.* (2006) and Norris *et al.* (2011) also documented that temperate breeds produce more milk than tropical breeds. Moreover, breed is a major factor influencing animal production performance, as noted by Sangare and Pandey (2000). However, Zharaddeen *et al.* (2009) reported that Sahelian goats yielded more milk than Red Sokoto goats in natural habitats. Our study also found that the peak of milk yield decreased as lactation weeks increased. This aligns with the report of Sangare and Pandey (2000), who observed that the peak of milk yield for Sahelian goats occurred in the first week of lactation before declining. However, Zharaddeen *et al.* (2009) reported that the peak of milk yield in the three predominant breeds in Nigeria occurred in the third week of lactation. Makun *et al.* (2013) observed the peak of milk yield in the fifth week of lactation in Red Sokoto and Sahelian goats. In addition, Akpa *et al.* (2002) noted that the highest peak of milk yield (44.1) during the lactation period of Red Sokoto goats occurred in the late dry season, while the lowest (23.8) occurred during the late wet season. Our study similarly recorded the highest milk yield of 46.3 during the late dry season. Adewumi *et al.* (2017) reported that the weight of kids significantly influenced milk yield in Kalahari Red goats, which is consistent with our findings that the number of kids per dam also had a significant effect on milk yield among the three indigenous goat breeds analyzed.

Our study revealed that the protein contents of Red Sokoto, Sahel, and West African dwarf goats (4.43%, 4.04%, and 4.62%, respectively) were lower than that of Sahelian goats (5.56%) reported by Ibeawuchi *et al.*, (2005), the Mexican Rambouillet ewes (5.21%) reported by Ochoa-Cordero *et al.,* (2002), and the Kalahari Red goats (5.16%) reported by Adewumi *et al.,* (2017). Nonetheless, the mean protein contents in our study were higher than the 3.0% reported in multiparous mixed-breed (Criollo x diary breeds, mainly French Alpine, Nubian, and Saanen) goats by Flores-Najera *et al.* (2021). In addition, the mean fat (3.23%) in Sahel goats in our study was lower than the 5.23% reported in Granadina goats in Spain (Ceballos *et al.,* 2009), 5.8% reported in multiparous mixed-breeds by Flores-Najera *et al.* (2021), and much lower than the reported value of 7.61% in Sahel goats (Ibeawuchi *et al.,* 2005) and 7.58% (Adewumi *et al.,* 2017).

The total solids mean value of Sahel goats (15.70%) in our study was higher than that of the West African Dwarf (18.30%) (Mba *et al.*, 1975) and Kalahari Red goats (18.84%) (Adewumi *et al.*, 2017) but comparable to Red Sokoto (15.85%) goat milk (Mba *et al.,* 1975). However, the mean total solid value of Red Sokoto goats (17.22%) in this study was higher than the reported value in Red Sokoto (15.70%) by Mba *et al.* (1975). The present total solids value in West African dwarf (16.09%) was comparable to the values of 16.60% reported by Saanen (Pilla *et al.,* 1980) and Alpine goat milk (Varna and Chawia, 1984).

Furthermore, the overall mean of solid-nonfat among the Red Sokoto, Sahel, and West African dwarf (13.93%, 12.90%, and 13.66%, respectively) were higher than the reported values. For example, Mba *et al.* (1975) reported lower values in Red Sokoto (4.60%) and West African Dwarf (4.17%) goat milk. Flores-Najera *et al*., (2021) also reported a lower value in multiparous mixed-breed (8.2%) goat milk. However, Adewumi *et al.* (2017) reported 11.27% of solid-not fat in the Kalahari Red goats. The ash content in the Red Sokoto, Sahel, and West African dwarf goats (0.93%, 0.87%, and 0.90%) respectively were higher than in Kalahari Red goats (0.54%) (Adewumi *et al.,* 2017) but comparable to 0.78% of Indian goats (Quresh *et al*., 1981).

CONCLUSION

Our findings on the Red Sokoto, Sahel, and West African dwarf breeds of goats demonstrate that milk compositions vary across these breeds, and milk yield could be affected by breeds, lactation week, and the number of kids per dam of these breeds.

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REFERENCES
Abbas, H. M., Hassan, F. A. M., Abd El-Gawad, A. M. M. and Enab, A. K. (2014). Physicochemical Characteristics of Goat's Milk. *Life Science Journal*, 11(1s):307-317.

Adewumi, O. O., Oluwatosin, B. O., Tona, G. O., Williams, T. J. and Olajide, O. O. (2017). Milk yield and milk composition of Kalahari Red goat and the performance of their kids in the humid zone. *Archivos de Zootecnia*, Vol. 66, núm. 256, pp. 587-592.

Akpa, G. N., Asiribo, O. E., Oni, O. O., Alawa, J. P., Dim, O. A. *et al.* (2002). Milk production by agropastoral Red Sokoto Goats in Nigeria. *Tropical Animal Health and Production*, 34. 525-533.

AOAC. (2012). Nonprotein nitrogen in whole milk. Kjeldahl method, method no. 991.21. In GW Latimer Jr (Ed.), Official methods of analysis of AOAC International (19th ed.). Gaithersburg, MD, USA: AOAC International. www.aoac.org (accessed 2023.03.03).

Baenyi, S. P., Junga, J. O., Tiambo, C. K., Birindwa, A. B., Basengere, R. A. *et al.* (2021). Phenotypic traits, reproductive and milk production performances of indigenous goats in south Kivu, democratic republic of Congo. *Journal of Applied Biosciences* 168: 17477 – 17493.

Ceballos, L. S., Morales, E. R., Adarve, G. T., Castro, J. D., Martínez, L. P. *et al.* (2009). Composition of goat and cow milk produced under similar conditions and analyzed by identical methodology. *Journal of Food Composition Analysis*. 22 (4): 322-329. https://doi.org/10.1016/j.jfca.2008.10.020.

Croissant, A. E., Washburn, S. P., Dean, L. L., & Drake, M. A. (2007). Chemical properties and consumer perception of fluid milk from conventional and pasture-based production systems. *Journal of dairy science*, 90(11), 4942–4953. https://doi.org/10.3168/jds.2007-0456.

Devendra, C. (2013). Investments on Pro-poor Development Projects on Goats: Ensuring Success for Improved Livelihoods. *Asian-Aust. J. Anim. Sci.* 26:1-18.

DeVriesa, J. W., Greeneb, G. W., Paynec, A., Zbyluta, S., Scholld, P. F. *et al.* (2017). Non-protein nitrogen determination: a screening tool for nitrogenous compound adulteration of milk powder. doi.org/10.1016/j.idairyj.2016.12.003.

FAOSTAT. (2012). Food and Agriculture Organization of the United Nations Data. Statistical Databases. http://faostat.fao.org/default.aspx?lang=en.

Flores-Najera, M. J., Cuevas-Reyes, V., Vázquez-García, J. M., Beltrán-López, S., Meza-Herrera, C. A. *et al.* (2021). Milk yield and composition of mixed-breed goats on rangeland during the dry season and the effect on the growth of their progeny. *Biology*, 10, 220. https://doi.org/10.3390/biology10030220.

Gallier, S., Tolenaars, L., and Prosser, C. (2020). Whole Goat Milk as a Source of Fat and Milk Fat Globule Membrane in Infant Formula. *Nutrients*, *12*(11), 3486.

Goswami, M., Bharti, S. K., Tewari, A., Sharma, H., Karunakara, K. N. *et al.* (2017). Implication of functional ingredients of goat milk to develop functional foods. *Journal of Animal Feed Science and Technology*. 5 65-72.

Guney, O., Torun, O., Ozuyanik, O. and Darcan, N. (2006). Milk production, reproductive and growth performances of Damascus goats under Northern Cyprus conditions. *J Small Rumin Res.* 65: 176-179.

Haenlein, G. F. W. (2003). Goat milk in human nutrition. *Small Ruminant Research* 51. 155–163.

Ibeawuchi, J. A., Ahamefule, F. O. and Ringim, I. A. (2005). The influence of lactation stage on the milk constituents of Sahelian goats. *Nigerian Soc Anim Prod.,* 30: 259-264.

Idowu, S. T. and Adewumi, O. O. (2017). Genetic and Non-Genetic Factors Affecting Yield and Milk Composition in Goats. *J Adv Dairy Res.,* 5:175. doi:10.4172/2329-888X.1000175.

Khaskheli, M., Arain, M. A., Chaudhry, S., Soomro, A. H. and Qureshi, T. A. (2005). Physico-chemical quality of camel milk. *Journal of Agriculture and Social Sciences* 1813–2235/2005/01–2–164–166.

Kendall, P. E., Nielsen, P. P., Webster, J. R., Verkerk, G. A., Littlejohn, R. P. *et al.* (2009). The effects of providing shade to lactating dairy cows in a temperate climate. *Livestock Sci*., 103: 148-157.

Luo, J., Wang, W. and Sun, S. (2019). Research advances in reproduction for dairy goats. *Asian-Australas J Anim Sci.* 32(8):1284-1295. doi: 10.5713/ajas.19.0486. Epub 2019 Jul 18. PMID: 31357269; PMCID: PMC6668861.

Makun, H. J., Ajanusi, J. O., Ehoche, O. W., Lakpini, C. A. M. and Otaru, S. M. (2008). Growth rates and milk production potential of Sahelian and Red Sokoto breeds of goats in northern Guinea Savannah. *Pakistan Journal of Biological Sciences,* 11 (40): 601–606. https://doi.org/10.3923/pjbs.2008.601.606.

Makun, H., Otaru, S. M. and Dung, D. (2013). Effect of management practices on milk yield and live weight changes of indigenous breeds of goats supplemented with groundnut haulms and concentrate in sub humid zone of Nigeria. *Sokoto Journal of Veterinary Sciences* (2013) 11(1): 45-50.

Mba, A. U., Boyo, B. S. and Oyenuga, V. A. (1975). Studies on the milk composition of West African Dwarf, Red Sokoto and Sahel goats at different stages of lactation. *J Diary Res.,* 42: 217-226.

Mestawe, T. A., Girma, A., Ådnøy, T., Devold, T. G., Narvhus, J. A. *et al.* (2012). Milk production, composition and variation at different lactation stages of four goat breeds in Ethiopia. *Small Ruminant Research*, 105: 176– 181.

Mohsin A. Z., Sukor, R., Selamat, J., Meor Hussin, A. S. and Ismail I. H. (2019). Chemical and mineral composition of raw goat milk as affected by breed varieties available in Malaysia. *International Journal of Food Properties*, 22(1): 815–824.

Norris, D., Ngambi, J. W., Benyi, K. and Mbajiorgu, C. A. (2011). Milk production of three exotic dairy goat genotypes in Limpopo Province, South Africa. *Asian J Anim Vet Adv*., 6: 274 - 281.

Nayik, G. A., Jagdale, Y. D., Gaikwad, S. A., Devkatte, A. N., Dar, A. H., Dezmirean, D. S., *et al.* (2021). Recent Insights into Processing Approaches and Potential Health Benefits of Goat Milk and Its Products: A Review. *Frontiers in nutrition*, *8*, 789117.

Ochoa-Cordero, M. A., Torres, H. G., Ochoa, A. E., Vega-Rogue, L. and Mandeville, P. (2002). Milk yield and composition of Rambouillet ewes under intensive management. *Small Rum Res.,* 43: 269-274.

Odunsi, A. A., Togun, V. A. and Oladunyoye, I. O. (2005). Introduction to animal production and processing. *Oluseyi Press Limited*, Nigeria.

Oliver, S. P., Jayarao, S. P. and Almeida, R. A. (2005). Foodborne pathogens in milk and the dairy farm environment: Food safety and public health implications. *Foodborne Pathogens and Diseas.* Volume 2, Number 2.

Park, Y. W. (2017). Goat milk-chemistry and nutrition. *Handbook of Milk of Non-Bovine Mammals*, 42–83. doi: 10.1002/9781119110316.ch2.2.

Pilla, A. M., Delli, A. S., Scardelfa, P., Taibi, L. and Tarka, L. (1980). Milk production by Gargano, Maltese and Sannen goats. *Annalida Insitution Sperimentale Per la Zootecnica,* 12:143-150.

Prosser, C. G. (2022). Compositional and functional characteristics of goat milk and relevance as a base for infant formula. Journal of Food Science. Vol. 86, Iss. 2:257 – 265. doi: 10.1111/1750-3841.15574.

Sangare, M. and Pandey, V. S. (2000). Food intake, milk production and growth of kids of local, multipurpose goats grazing on dry season natural Sahelian rangeland in Mali. *Journal of Animal Science* 71*: 165-173.*

Silanikove, N., Leitner, G., Merinc, U. and Prosser, C. G. (2010). Recent advances in exploiting goat's milk: Quality, safety and production aspects. *Small Ruminant Research*, 89 110–124.

Quresh, H. A., Desh-Pande, K. S. and Bondell, S. (1981). Study of chemical composition of goat milk. *Indian Vet J,* 58: 212-214.

Varna, N. K. and Chawla, D. (1984). Variation of milk composition in dairy goats. *Indian J Anim Sci,* 5: 539-543.

Yu, Y., Lai, S., Chang, C., Chen, W., Wu, S. *et al.* (2021). Peptidomic analysis of low molecular weight antioxidative peptides prepared by lotus (*Nelumbo nucifera* Gaertn.) seed protein hydrolysates. *Food Science and Technology* 144. 111138.

Zahraddeen, D., Butswat, I. S. R. and Mbap, S. T. (2009). A note on factors influencing milk yield of local goats under semi-intensive system in Sudan savannah ecological zone of Nigeria. *Livestock Research for Rural Development*, 21 Article #34 from http://www.lrrd.org/lrrd21/3/zahr21034.htm, retrieved 2013-04-05.

Zhang, J., Xu, C, Huo, D., Hu, Q. and Peng, Q. (2017). Comparative study of the gut microbiome potentially related to milk protein in Murrah buffaloes (*Bubalus bubalis*) and Chinese Holstein cattle. *Scientific Reports.* 7:42189. doi: 10.1038/srep42189.