



EFFECTS OF DIFFERENT PROTEIN SOURCES DIETS ON MILK YIELD AND COMPOSITION OF WHITE FULANI COWS

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ABSTRACT

This study was conducted to determine the effects of different protein source diets on milk yield and composition of lactating White fulani cows. A total of 20 lactating White fulani cows were selected and treated against diseases prior to the commencement of the experiment and randomly assigned to 4 treatment groups with 5 replicates in a Completely Randomized Design. The treatment groups consisted of T0 (formulated diet as control), T1 (23% copra meal/100 kg diet), T2 (23% cottonseed cake/100 kg diet), and T3 (23% soybean milk residue/100 kg diet). The experiment lasted for 8 weeks, and the parameters measured include feed intake, weight gain, milk yield and composition. The chemical composition of the diets varied significantly ($P < 0.05$), with T2 showing the highest crude protein (14.33%) and ether extract (2.72%), while T3 had significantly higher fibre fractions (ADF 38.10%; NDF 59.06%). The results showed that, cows fed with 23% cotton seed cake/100 kg diet (T2) had significantly ($P < 0.05$) higher total milk yield (128.60 kg), daily milk yield (3.05 kg/day) and feed conversion efficiency (0.55). Milk composition parameters also significantly ($P < 0.05$) differed, with T2 recording the highest milk fat (5.10%), milk protein (3.50%), total solids (15.46%), ash (0.81%), and the lowest somatic cell count ($180 \times 10^3/\text{mL}$), indicating superior udder health and nutrient partitioning. In contrast, T3 consistently showed significantly ($P < 0.05$) lower values for these parameters, attributed to its higher fibre and lignin content, which reduced nutrient digestibility. This finding suggested that 23% cottonseed-cake/100 kg diet (T2) can be used as protein supplement to improve milk yield and composition, making it the recommended protein source for enhancing dairy productivity in indigenous cattle raised under tropical conditions.

Keywords: Protein, Source, Milk, Yield and Composition

INTRODUCTION

Milk production plays a crucial role in the livelihood of rural households in Nigeria, where indigenous breeds such as the Bunaji (White Fulani) cow are predominant due to their adaptability to local climatic conditions, disease resistance, and moderate milk yield (Tambuwal *et al.*, 2002). However, the productivity of these cows, particularly during lactation, is often limited by nutritional deficiencies, especially in protein intake, which is critical for optimal milk production, reproduction, and overall health (Wu, 2010). In tropical regions, natural pastures tend to decline in quality during the dry season, with a marked reduction in crude protein content, which adversely affects the performance of lactating cows (Abbator *et al.*, 2017). Protein supplementation has thus become a common practice to improve feed quality and maintain production levels. Supplemented Protein can influence the nutrient utilization. The groundnut cake and soybean meal are commonly using protein supplemented but there are expensive and competition with human consumption and the feed industry (FAO, 2012). However, attention has been moving for potential alternative protein sources, such as cottonseed cake, and copra meal, which may reduce feed cost. Studies have shown that combining different protein sources or selecting those with higher bypass protein can enhance milk yield and maintain body condition in lactating cows (Broderick *et al.*, 2008). This study is therefore designed to investigate the performance



response specifically in terms of milk yield and composition of lactating Bunaji cows fed different protein sources supplements.

MATERIALS AND METHODS

Study Location

The study was conducted at the Livestock experimental Farm, Farming system Research Department, Lake Chad Research Institute, Maiduguri. Maiduguri lies within latitude 11°50'N and longitude 13°09'E and has an elevation of 320 m above mean sea level (BOSHIC, 2007). The mean ambient temperature could be as low as 23°C during the cold season and gets as high as 40°C or more during the hot season. Relative humidity is about 30-45% in August which usually drops to about 5% in the months of December and January and has evaporation of 203 mm/year. Day length varies from 11 to 12 hours (BOSHIC, 2007).

Source and Preparation of Feed

The wheat straw and sorghum stover were sourced at LCRI demonstration Farm, while the other feed ingredients were sourced at Gamboru Cattle Market, Maiduguri. Wheat offal, sorghum stover, Maize bran and wheat straw were used as energy sources, while cotton seed cake, copra meal and soya bean milk residue as protein sources. Bone meal and common salts were used as minerals sources. Following the procurement of all feed ingredients that satisfy the target animals' nutritional requirements, the straw and stover were chopped into small pieces to guarantee uniformity of diet composition, and efficient mixing.

Treatment/Experimental diets

Three (3) different experimental diets were formulated using cotton seed cake, copra meal and soya bean milk residue, maize bran, sorghum stover, wheat straw, wheat offal, bone meal and salts as shown T0 – Control (formulated diet), T1 – A diet containing 23% copra meal as the protein source, T2 – A diet containing 23% cotton seed cake as the protein source and T3 – A diet containing 23% soya bean milk residue as the protein source.

The formulated diet that was used as the control (T0) is a mixture of cowpea haulms (20%), wheat offal (20%), millet husk (40%) and maize bran (20%).

Experimental Animals and their Management

A total of (20) White Fulani with average weight of 250 kg was used for the experiment for the period of eight (8) weeks. The animals were sourced from the Livestock experimental Farm, Farming System Research Department, Lake Chad Research Institute, Maiduguri. The animals were randomly allocated to one of four treatment groups in individual pens with adequate ventilation and throughout this period, the animals were going out for grazing in the morning and the experimental diet was given as supplement in the evening at 3% of their body weight and water was also given ad-libitum. The animals were treated prior to the commencement of the experiment against internal parasites with broad spectrum anthelmintic Zanisol (2400 mg/150 kg) and injected with broad spectrum antibiotic (Oxytetracycline) and Multivitamin at 1ml/10 kg body weight.

Experimental Design and Feeding

The animals were allotted to 4 treatments; five (5) animals were randomly allocated to each treatment in a Complete Randomized Design (CRD) and each cow serves as a replicate. The animals were placed to a different pen with adequate ventilation. The feed intake and milk yield were measured on a daily basis and the experimental diets was offered as supplement at 1.5% of their body weight in the morning at milking times and 1.5% in the evening after the animals must have return from grazing.

Performance Parameters

The performance parameters measured were: feed intake, weight gain, milk yield and composition and feed conversion efficiency. Determination of milk fat content, total solids content, crude protein content, ash content, lactose content, moisture content and somatic cell count.

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) using the statistical package (statistix 8.0) and the differences between the means were separated using the Least Significance Difference at 5% level of probability.

RESULTS AND DISCUSSION

Chemical Composition of Experimental Diets

The chemical composition of the experimental diets is presented in Table 1. The result revealed that, dry matter (DM), ether extract (EE), crude protein (CP), crude fibre (CF), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), nitrogen free extract (NFE) and lignin (LIG) contents were significantly ($P < 0.05$) different among the treatments. T3 and T0 had significantly higher DM content compared with T1 and T2. The highest CP value (14.33%) was obtained in T2 while the least (10.47%) was in T0. Also, T0 had the highest CF value (30.89%) while the least value (21.72%) was in T2. Also, T2 had the highest EE value (2.72%) while T3 had the least value (1.80%). Ash content, an indicator of total mineral concentration, was higher (6.15%) in T3 and lower (2.44%) in T2 (2.41%). ADF was highest in T3 (38.10%) and lowest in T0 (30.68%). T3 had the highest NDF value (59.06%) while the least value (49.49%) was observed in T2. NFE was highest in Control (52.23%) and lowest in T3 (42.30%).

Table 1: Chemical Composition of the Experimental Diets

Formulations	Proximate Composition								
	DM	CP	CF	EE	Ash	NFE	NDF	ADF	LIG
T ₀	94.41 ^a	10.47 ^c	30.89 ^a	1.89 ^c	4.52 ^b	52.23 ^a	51.32 ^c	30.68 ^d	7.86 ^b
T ₁	93.36 ^c	12.11 ^b	24.56 ^c	2.51 ^b	2.600 ^b	45.06 ^c	55.03 ^b	35.16 ^b	8.01 ^b
T ₂	93.79 ^b	14.33 ^a	21.72 ^d	2.72 ^a	2.44 ^d	47.51 ^b	49.49 ^d	31.640 ^c	6.89 ^c
T ₃	94.44 ^a	11.50 ^c	28.00 ^b	1.80 ^c	6.15 ^a	42.30 ^d	59.06 ^a	38.10 ^a	9.13 ^a
SEM	0.03 [*]	0.08 [*]	0.26 [*]	0.04 [*]	0.01 [*]	0.64 [*]	0.47 [*]	0.20 [*]	0.05 [*]

Key: DM = Dry matter, CP = Crude protein, CF = Crude fibre, EE = Ether extract, NFE = Nitrogen free extract, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, LIG = Lignin

a, b, c = means in the same row with different super scripts are significantly ($P < 0.05$) different

NS =Not significantly ($P > 0.05$) different

SEM =Standard error of mean

* = Significantly ($P < 0.05$) different

The DM values obtained in this study (93.36–94.44%) are consistent with those reported by Akinola *et al.* (2018), who recorded DM values ranging from 93.2% to 95.1% in compounded rations for lactating cows. Similarly, Oladipo and Olayemi (2020) observed that improved drying and balanced ingredient proportions significantly enhanced dry matter concentration in dairy feed formulations. The high DM value in T3 suggests better dehydration and nutrient density, which is desirable for improving the energy content of feed and enhancing milk production efficiency.

These findings are in agreement with the report of Akinfemi *et al.* (2012), who observed that diets formulated with higher proportions of leguminous forages or oilseed cakes exhibited increased CP values, typically ranging between 13.5% and 16.2%. Similarly, Oni *et al.* (2010) reported CP values of 14–15% in ruminant diets containing improved browse plants, aligning closely with the CP content obtained in T2 of this study. Conversely, the lower CP content in T3 (10.50%) is comparable to the findings of Adejumo *et al.* (2019), who reported CP levels of about 10–11% in feed mixtures composed mainly of cereal residues with minimal protein supplements. The relatively high CP in T2 could therefore translate into improved growth rates, milk production, or reproductive performance depending on the target class of livestock.

The highest Crude fibre (CF) value was record in control (T0) (30.89%) while the lowest value in cotton seed cake T2 (21.72%). The CF content in this study with except of control are similar with report of Oladimeji *et al.* (2024) reported values between 20.15% and 27.36% for cassava peel-based rations. Also, Aro and Aletor (2012) observed CF values between 22.10% and 28.50% in cassava root and peel mixtures. The findings are analogous to the present study, mainly with cotton seed cake (T2) (21.72%) and control (T0) (30.89%), indicating uniformity with recognized results on fibrous feed ingredients.



Ether extract (EE) content showed highly significant ($P < 0.05$) difference among the treatment group, with T2 (cotton seed cake) have been highest value (2.72%) while soya bean milk residue T3 was lowest (1.80%). The EE value obtained in this study is similar with the reported by Aduku (2004), who stated that the EE content of most ruminant feeds ranges from 1.5% to 4.0%. Similarly, Ogunjimi *et al.* (2012) observed EE values ranging from 1.72% to 2.45% in formulated rations for dairy cattle, which similar with the current results. The relatively higher EE value in cotton seed cake (T2) (2.72%) suggests that the feed might offer higher energy density, possibly to improving feed utilization and milk fat content.

Fibre fractions, particularly acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents, differed significantly ($P < 0.05$). soya bean milk residue T3 recorded the highest ADF (38.10%) and NDF (59.06%) values, while T2 had the lowest ADF (31.64%) and NDF (49.49%) contents. ADF is strictly connected to digestibility, as it includes cellulose and lignin, which are less digestible components of plant material. The high lignin content of soya bean milk residue T3 suggests poor digestibility and reduced nutrient utilization while cotton seed cake T2 had the lowest lignin content had better digestibility. This result is in line with the findings of Jung and Allen (1995), who reported that lignin is the primary factor limiting forage digestibility and that reducing lignin levels in feed formulations enhances energy availability. The present findings bring into line with the report of McDonald *et al.* (2010), who noted that diets with higher NFE values generally promote better animal performance due to the increased supply of fermentable energy. The lower NFE content in soya bean milk residue (T3) can limited energy density compared to (T2 cotton seed cake).

Performance of Lactating Bunaji Cows Fed Diets Containing Different Protein Sources

The results of Performance of Lactating Bunaji Cows is presented in Table 2. The results showed significant ($P < 0.05$) difference in total milk yield, daily milk yield and feed conversion efficiency, while daily supplement intake and mean body weight showed no significant ($P > 0.05$) differences among the treatment groups. The highest value (128.60 Kg) total milk yield was observed in T2 (cotton seed cake) while the control had the lowest value (40.20 Kg) milk output. The results indicate that the inclusion of the cotton seed cake in T2 obviously improved milk production efficiency in the Bunaji cows compared to the control and copra meal (T1). The highest FCE values were observed in T2 (0.55) and the control (0.22) recorded lower values. The improvement in FCE in T2 implies that cows on this diet converted feed nutrients into milk more efficiently compared to those on the other treatment groups.

Table 2: Performance of Lactating Bunaji Cows Fed Experimental Diets

Parameters	T0	T1	T2	T3	SEM
Total Milk Yield (Kg)	40.20 ^d	59.40 ^c	128.60 ^a	100.20 ^b	0.11 [*]
Daily Milk Yield (Kg/head/day)	0.95 ^d	1.39 ^c	3.05 ^a	2.38 ^b	4.66 [*]
Daily Supplement Intake (Kg/head/day)	4.34 ^a	4.87 ^a	5.50 ^a	4.55 ^a	0.64 ^{NS}
Mean Body Weight (Kg)	260 ^a	256 ^a	273 ^a	261 ^a	3.67 ^{NS}
Feed Conversion Efficiency	0.22 ^b	0.28 ^b	0.55 ^a	0.52 ^a	0.083 [*]

Key: a, b, c, d= means in the same row with different super scripts are significantly ($P < 0.05$) different
NS =Not significantly ($P > 0.05$) different

SEM =Standard error of mean

* = Significantly ($P < 0.05$) different

The significant improvement in milk yield among cows on (T2) suggests that the cotton seed cake diet provided better nutrient balance, perhaps improving rumen fermentation and nutrient utilization. The results of this finding which in line result with report of Abdullahi *et al.* (2022), supplementation with energy- and protein-rich concentrates promotes microbial activity in the rumen, leading to higher milk yield and feed efficiency in lactating cows. Similarly, Akinlade *et al.* (2021) reported that Bunaji cows fed concentrate diet showed significantly higher milk yield than control similar with the present findings which control with supplement had poor performance. The higher

performance observed in diet cotton seed cake T2 may be attributed to better nutrient utilisation, which are firm causes of milk production competence. According to Aljumaah *et al.* (2012), enhancing nutrient density important in increases daily milk yield. Similarly, Nkya *et al.* (2019) reported that cows fed balanced rations with high energy and protein showed higher milk yield compared to those on poorly formulated diets. The relatively low milk yield observed in T0 control is consistent with findings by Hossain *et al.* (2017), who reported that inadequate nutrient supply results in reduced milk output due to limited substrate availability for lactose synthesis, which physiologically governs milk volume. Additionally, Sastry and Thomas (2018) highlighted that imbalanced or low-quality diets negatively affect feed intake and rumen fermentation, ultimately reducing daily milk production.

A higher FCE in T2 indicates an optimal balance between energy and protein availability, supporting better metabolic efficiency. This is consistent with Eze *et al.* (2023), who reported that cows fed balanced energy–protein diets achieved superior milk output per unit of feed consumed. Likewise, Adesina and Oyediji (2020) highlighted that supplementing Bunaji cows with energy-dense concentrates enhanced feed efficiency and overall productivity under tropical conditions. The relatively lower FCE in the control and T1 groups suggests that feed nutrients were not efficiently utilised, possibly due to nutrient deficiencies or poor digestibility. According to Oluremi *et al.* (2022), nutrient-deficient diets increase maintenance energy costs and reduce milk yield, thereby lowering FCE.

MILK COMPOSITION OF LACTATING BUNAJI COWS FED DIETS CONTAINING DIFFERENT PROTEIN SOURCES

The effects of different protein sources supplement diets on milk composition of Bunaji cows is presented in Table 3. The results revealed significant ($P < 0.05$) difference in all parameters measured except lactose across the treatments.

Table 3: Milk Composition of Lactating Bunaji Cows Fed Experimental diets

Formulations	Milk Composition							
	MF	MP	Lactose	TS	SCC	MUN	Ash	MOIS
T0	4.72 ^b	2.95 ^b	4.53 ^a	11.42 ^b	200.00 ^c	23.87 ^c	0.73 ^b	88.10 ^b
T1	4.36 ^b	3.33 ^{ab}	4.60 ^a	10.60 ^c	250.00 ^b	27.93 ^b	0.70 ^b	89.40 ^a
T2	5.10 ^a	3.50 ^a	4.64 ^a	15.46 ^a	180.00 ^d	30.86 ^a	0.81 ^a	84.53 ^c
T3	3.80 ^c	2.90 ^b	4.36 ^a	10.40 ^c	300.00 ^a	24.13 ^c	0.60 ^c	89.530 ^a
SEM	0.07 [*]	0.16 [*]	0.13 ^{NS}	0.23 [*]	5.04 [*]	0.59 [*]	0.01 [*]	0.22 [*]

Key: MF = Milk fat, MP = Milk protein, TS = Total solid, SCC = Somatic cell count, MUN = Milk urea nitrogen, MOIS = Moisture

a, b, c, d = means in the same column with different super scripts are significantly ($P < 0.05$) different

NS = Not significantly ($P > 0.05$) different

SEM = Standard error of mean

* = Significantly ($P < 0.05$) different

The higher milk fat and milk protein contents observed in T2 could be attributed to better nutrient composition, especially the availability of adequate energy sources in the diet, which enhances milk fat synthesis. According to Okonkwo *et al.* (2018), milk fat and protein contents is strongly influenced by the balance of fibre and readily fermentable nutrient in the feed, as these affect rumen fermentation and volatile fatty acid production particularly acetate, which is a major precursor for milk fat synthesis.

This finding is in agreement with the report of Adegbola and Oduozo (2015), who observed that cows fed diets with balance energy produced higher milk fat percentages (ranging from 4.8% to 5.3%) compared to cows fed low energy diet. Also, Ekeocha *et al.* (2020) stated that improved fat content (5.12%) was obtained when dairy cows were supplemented with energy diet, while lower values were recorded in cows on low quality roughages. However, the lower fat content obtained in T3 (3.80%) aligns with the findings of Ahmed *et al.* (2017), who reported reduced milk fat levels in cows fed diets with low fibre and high concentrate proportions, resulting in decreased acetate formation in the rumen.



The milk protein content observed in this study falls within the normal range of 2.8% to 3.6% reported for dairy cows by McDonald *et al.* (2010) higher milk protein T3 probably due high energy of diet based chemical composition result of this study

In the current study, T2 recorded the highest total solids (TS) value (15.46%), while T3 had the lowest value (10.40%). The higher TS concentration observed in T2 suggests a better nutrient profile and may be attributed to improved feed quality, higher dry matter intake, or better digestibility leading to enhanced nutrient partitioning toward milk synthesis. Conversely, the lower TS content in T3 indicates reduced nutrient availability or possible dilution effects. These findings are consistent with the reports of O'Callaghan *et al.* (2016), total solids in cow milk typically range between 12 and 15%, depending on breed, diet composition, physiological state, and environmental stressors. Similarly, Auld and Thomson (2020) noted that improved dietary energy density significantly increases milk total solids, supporting the result of this finding of higher TS value seen in T2. In another related study, Singh *et al.* (2018) reported TS values ranging from 11.5 to 14.8%, which closely with the current findings, especially with the high value observed in T2.

Somatic cell count (SCC) diverse among the treatment groups, with T3 recording the highest value of 300×10^3 cells/mL while T2 had the lowest value of 180×10^3 cells/mL. This pattern is consistent with the general understanding that SCC increases in response to intramammary infection or udder tissue irritation. According to Alhussien and Dang (2018), SCC values below 100,000 cells/mL are typically associated with healthy mammary glands, whereas counts exceeding 200,000 cells/mL often indicate the presence of subclinical mastitis. Therefore, the SCC level observed in T2 (180×10^3 cells/mL) falls slightly below commonly reported infection thresholds and suggests relatively good udder health among cows in this group. Comparatively, the value recorded for T3 (300×10^3 cells/mL) aligns with threshold ranges anticipated by report for the diagnosis of subclinical mastitis. Jadhav *et al.* (2018) recognized an SCC threshold of approximately 310×10^3 cells/mL as indicative of subclinical intramammary infection, demonstrating that the T3 value in the present study approximates this diagnostic point. Similarly, industry-level benchmarks reported by Schwarz *et al.* (2010) classify bulk or composite milk SCC values below 150,000–200,000 cells/mL as characteristic of well-managed herds, whereas values around 300,000 cells/mL often reflect increased mastitis prevalence within the herd. This further supports the interpretation that cows in the T3 group may have experienced higher udder health challenges compared to those in T2. Additional literature has documented that SCC values comparable to those obtained in T2 (180,000 cells/mL) are typical for farms with good udder health status, while values around 300,000 cells/mL similar to those found in T3 are frequently observed in herds experiencing elevated levels of intramammary infection (38). Furthermore, increases in SCC have been consistently associated with reduced milk quality and production efficiency. Ma (2000) reported that elevated SCC, particularly values above 250,000 cells/mL, are linked to declines in milk composition, shelf life, and processing properties. Thus, milk from the T3 treatment group may have been more prone to reduced quality compared with milk from T2.

The ash content of milk varied significantly ($P < 0.05$) among the treatment groups, with T2 recording the highest value (0.81%) and T3 the lowest (0.60%). These findings fall within the typical ash range (0.5–1.0%) reported for bovine milk in the literature. Similarly, NRC (1988) documented mean ash concentrations around 0.70%, indicating that both T2 and T3 remain consistent with expected mineral levels in dairy cattle. Studies conducted in Nigeria by Aliyu *et al.* (2019) also reported ash values ranging from 0.60 to 0.79%, further supporting the observation that T3's lower value is still within a normal range for raw milk. Variations among treatment groups may be influenced by differences in diet, mineral supplementation. As milk ash content reflects the total mineral composition, differences between T2 and T3 may therefore be attributed to disparities in mineral intake or absorption efficiency.

Significant differences ($p < 0.05$) were also observed in milk urea nitrogen (MUN) values, which were highest in T2 (30.86 mg/dL) and lowest in T3 (24.13 mg/dL). Elevated MUN levels are associated with increased intake of rumen-degradable protein, indicating that the protein source in T2 was more degradable. Broderick *et al.* (2008) explained that MUN serves as a useful indicator of nitrogen



metabolism and protein utilisation efficiency, where higher values reflect greater protein breakdown and urea formation

CONCLUSION AND RECOMMENDATION

Based on the results of this study, it was concluded that protein supplementation significantly influenced the milk yield and composition of lactating Bunaji cows. Diet T2 provided the most optimal nutrient balance, resulting in improved milk composition, feed conversion efficiency, and animal health. Therefore, this finding recommended the formulation T2 should be adopted as protein supplement for enhancing milk yield and quality in White fulani cows in a semi-arid region of Nigeria.

REFERENCES

- Abbator. F. I., Kolo. U. M., Audu. R. M. Taimako and Kwaghe A. L. (2017). Performance of Goats Fed Bovine Rumen Content and Wheat Offal as Supplement to Groundnut Haulms *Global Journal of Agricultural Research*, 5(2): 11-19.
- Abdullahi, M. A., Umar, H. I. and Ahmed, S. (2022). Effect of dietary supplementation on milk production performance of Bunaji cows. *Nigerian Journal of Animal Production*, 49(3): 45–53.
- Adegbola, T.A., and Oduozo, O.O. (2015). Performance of Bunaji cows under smallholder dairy production systems in northern Nigeria. *Tropical Animal Health and Production*, 47(1): 65–71.
- Adejumo, I. O., and Ademosun, A. A. (2019). Nutrient composition and feeding value of some tropical feed ingredients for ruminants. *Nigerian Journal of Animal Science*, 21(2): 45–54.
- Adesina, A. A. and Oyediji, A. (2020). Feed conversion efficiency and milk yield response of Bunaji cows to dietary concentrate supplementation. *Journal of Animal Science Research*, 10(2): 67–75.
- Aduku, A. O. (2004). Animal Nutrition in the Tropics: Feeds and Feeding, Pasture Management, Monogastric and Ruminant Nutrition. Davcon Computers and Business Bureau, Zaria, Nigeria.
- Ahmed, S., Aliy, M., Ibrahim, N. and Amanuel, M. (2017). Perception of dairy cattle owners on oestrus synchronization and mass artificial insemination services in Jimma Zone, South Western Ethiopia. *Greener Journal of Agricultural Sciences*, 7(6): 137–144.
- Akinfemi, A., Adesanya, A. O. and Aya, V. E. (2012). Use of crop residues in livestock feeding: A review. *Nigerian Journal of Animal Science*, 14(1): 23–32.
- Akinlade, J. A., Okoruwa, V. O. and Saka, J. O. (2021). Nutritional strategies for improving milk yield in indigenous dairy cows under smallholder systems. *Tropical Animal Health and Production*, 53(6): 1–9.
- Akinola, A. O., Ojo, V. O. A. and Adesina, M. A. (2018). Nutrient composition and dry matter evaluation of formulated rations for lactating dairy cows under tropical conditions. *Journal of Animal Science Research*, 6(2): 45–52.
- Alhussien, M. N. and Dang, A. K. (2018). Milk somatic cells, factors influencing their release, future prospects, and practical utility in dairy production. *Frontiers in Veterinary Science*, 5: 1–17.
- Aliyu, Y., Abdullahi, I. O., Whong, C. M. Z., Anumiri, C. E. and Bwala, J. D. (2019). The Proximate composition of Fresh and Fermented Milk in Parts of Nasarawa State, Nigeria. *Asian Food Science Journal*, 10(40), 1-12.
- Aljumaah, R. S., Samara, E. M. and Ayadi, M. (2012). Influence of introducing Milking machine on Biothermal parameters of Lactating Camels (*Camelus dromedarius*). *Italian Journal of Animal Science*, 11(4): 73.
- Aro, S. O. and Aletor, V. A. (2012). Proximate composition and amino acid profile of differently fermented cassava tuber wastes collected from a cassava starch producing factory in Nigeria. *Livestock Research for Rural Development*, 24(3): 102-106.
- Aro, S. O., Aletor, V. A., Tewe, O. O. and Agbede, J. O. (2010). Nutritional potentials of cassava tuber wastes: A case study of a cassava starch processing factory in south-western Nigeria. *Livestock Research for Rural Development*, 22(11): 42-47.



- Auldist, M. J. and Thomson, N. A. (2020). Nutrition and milk composition in dairy cows. *Animal Production Science*, **60**(2): 234–241.
- BOSHIC, (2007) Borno State Ministry of Home Affairs Information and Culture. <http://www.bornonigeria.com/index.php?option=com69:geography>
- Broderick, G. A., Stevenson, M. J., Patton, R. A., Lobos, N. E. and Schwab, C. G. (2008). Effect of dietary protein concentration and degradability on milk production and nitrogen utilization in lactating dairy cows. *Journal of Dairy Science*, **91**(11): 4340–4351
- Cerbulis, J. and Farrel, H. M. (1976). Composition of the Milks of dairy Cattle, Ash, Calcium, Magnesium and Phosphorus. *Journal of Dairy Science*, **59**(4): 589–593.
- Ekeocha, A. H., Aganga, A. A., Odumboni, A. A. and Giwa, O. J. (2020). Acceptability of processed meat products, Tsire (Suya), Kilichi and Danbunama, in Oye-Ekiti, Ekiti State, Nigeria. *Journal of Agriculture and Food Environment*, **7**(3): 46–56.
- Eze, C. C., Odo, B. I. and Ezeagu, I. E. (2023). Nutritional enhancement of indigenous dairy cattle through feed supplementation: Effects on milk production and efficiency. *Livestock Science*, **272**: 105–120.
- Food and Agriculture Organisation of the United Nations (2012). *World Livestock 2011-Livestock in Food Security*. Rome, Italy: FAO.
- Hossain, S. A., Sherasia, P. L., Phondba, B. T., Patel, B. P. and Garg, M. R., (2017). Feed conversion efficiency, Milk production and Methane emission in Cows Fed Balanced rations containing bypass protein feed. *Indian Journal of Animal Nutrition*, **34**(4): 359–366.
- Jadhav, P. V., Das, D. N., Parmar, S. C. and Shinde, K. B. (2018). Threshold somatic cell count for delineation of subclinical mastitis. *PLoS ONE*, **13**(11): 1–14.
- Jung, H. G. and Allen, M. S. (1995). Characteristics of plant cell walls affecting intake and digestibility of forages by ruminants. *Journal of Animal Science*, **73**(9), 2774–2790.
- Ma, Y. (2000). Effects of somatic cell count on dairy product quality. *Journal of Dairy Science*, **83**(10): 264–272.
- McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A. and Wilkinson, R. G. (2010). *Animal Nutrition (7th ed.)*. Pearson Education Limited.
- National Research Council (1988). *Nutrient Requirements of Dairy Cattle (6th rev. ed.)* Washington, DC: National Academy Press.
- National Research Council (NRC). (2001). *Nutrient Requirements of Dairy Cattle (7th rev. ed.)*. National Academy Press.
- Nkya, R., Kimambo, A. E. and Laswai, G. H. (2019). Effect of feed resources on blood metabolites of dairy cattle. *Tropical Animal Health and Production*, **51**(8): 2365–2374.
- O’Callaghan, T. F., Mannion, D. T. and Tobin, J. T. (2016). Effects of diet on milk composition and quality. *International Dairy Journal*, **56**: 1–9.
- Ogunjimi, L. A., Fajemisin, A. N. and Adeneye, J. A. (2012). Nutritional evaluation of some ruminant feed formulations. *Nigerian Journal of Animal Production*, **39**(1): 45–52.
- Oladimeji, S. O., Ogunwale, O. A., Adeyemi, A. A. and Tewe, O. O. (2024). Metabolisable energy value and anti-metabolites of cassava peels products in poultry. *Nigerian Journal of Animal Production*, 61–64. <https://doi.org/10.51791/njap.vi.4297>
- Okonkwo, V. N. and Esiegwu, A. C. (2018). Haematological and serum biochemical indices of finisher broilers fed Spondias mombin leaf meal. *Journal of Animal Science and Veterinary Medicine*, **3**(5): 165–170.
- Oladipo, F. O. and Olayemi, W. A. (2020). Influence of feed formulation and drying methods on proximate composition and nutrient retention in dairy cow feed. *African Journal of Livestock Science*, **15**(4): 210–219.
- Oluremi, O. I. A., Bamigboye, C. O. and Okonji, R. E. (2022). Nutrient utilization and milk yield of Bunaji cows fed varying concentrate levels. *Nigerian Veterinary Journal*, **43**(1): 25–31.
- Oni, A. O., Yusuf, A. O. and Aderinboye, R. Y. (2010). Chemical composition and nutritive value of some tropical forage legumes. *Proceedings of the Nigerian Society for Animal Production Conference*, **35**: 459–462.



- Sastry, N. S. R., Thomas, C. K. and Singh, R. A (2018). *Livestock Production Management* (6th ed.). New Delhi, India: Kalyani Publishers.
- Schwarz, D., Diesterbeck, U. S., König, S., Brügemann, K., Schlez, K., Zschöck, M., Wolter, W. and Czerny, C. (2010). Somatic cell counts and bacteriological status of quarter foremilk samples in dairy cows. *Journal of Dairy Research*, **77**(1): 63–70.
- Singh, R., Sharma, A. and Kaur, G. (2018). Milk quality variations in relation to feeding systems. *Asian Journal of Dairy Science*, **11**(1): 45–51.
- Tambuwal, F. M., Agale, B. M. and Alhassan, W. S. (2002). Body weight and linear measurements of Sahel goats. *Pakistan Journal of Biological Sciences*, **5**(6): 719–720.
- Wu, G. (2010). Functional amino acids in growth, reproduction and health. *Advances in Nutrition*, **1**(1): 31-37