Ogunbosoye et al., *Cogent Food & Agriculture* (2018), 4: 1474620
https://doi.org/10.1080/23311932.2018.1474620

cogent food & agriculture

ANIMAL HUSBANDRY & VETERINARY SCIENCE | RESEARCH ARTICLE

Blood profiles of West African dwarf (WAD) growing bucks fed varying levels of shea nut cake based rations in Nigeria

Dupe Olufunke Ogunbosoye[1]*, Abayomi Akinfemi[2] and David Aderemi Ajayi[3]

Received: 03 August 2017
Accepted: 30 April 2018
First Published: 11 May 2018

*Corresponding author: Dupe Olufunke Ogunbosoye, Department of Animal Production, Fisheries and Aquaculture, Kwara State University, Malete, Nigeria
E-mails: dupe.ogunbosoye@kwasu.edu.ng, olufunflory@gmail.com

Reviewing Editor:
Pedro González-Redondo, University of Seville,Spain

Additional information is available at the end of the article

Abstract: Shea nut cake (SNC) is one of the agro-industrial by-products that could be used as ruminants feed. A total of 12 West African dwarf young bucks were used in a completely randomized design for an 84-day study to evaluate the blood profiles of goats fed diets of 0 % (T1), 10% (T2) and 20% (T3)SNC. The results revealed that there were slight significant differences in few of the blood parameters measured among the treatments. The haemoglobin, packed cell volume (PCV) and red blood cell ranged from 8.33–9.88 g/dl, 20.95–22.05% and 6.51–7.06 × 10^6/l respectively. The concentrations of mean corpuscular volume (21.83–22.17 fl), mean corpuscular haemoglobin (7.58–8.50pg) and mean corpuscular haemoglobin concentration (33.00–34.73%) varied significantly ($p < 0.05$), white blood cell varied from 8.46 to 12.75 µl and lymphocytes (%) ranged from 51.27 to 53.78. For serum biochemistry, values obtained for aspartate aminotransferase and total protein were similar. Cholesterol, alanine amino transferase and albumin varied significantly among the treatment

ABOUT THE AUTHORS

Dr Dupe O. Ogunbosoye: I had researched into the solving feed problems that have become perennial issue to ruminant production in Nigeria and tropical countries in general. Alternative feed resources utilization has been discovered to be one of the ways to ameliorate feed scarcity often encountered during lean period. Most of my publications in this area have been published in most of the peer review journals.

Dr Abayomi Akinfemi: My field of research interest is ruminant nutrition and main research focus is treatment of agricultural wastes and by-products to value-added-ruminant feed. Agricultural wastes and by-products such as maize cobs, Sorghum straw and Sorghum threshed tops constitute environmental problems in Nigeria. My research work has been published in various journals.

Dr David A. Ajayi Exploration of alternative feed resources as a means of sustainable conservation of indigenous animal species with strong biases for small ruminants is the focus of my research activities with publications in peer reviewed journals and conference proceedings.

PUBLIC INTEREST STATEMENT

The inclusion of shea nut cake (SNC) in the diets of ruminants could be one of the strategies to ameliorate the dry season feeding problem in Nigeria. SNC is an agro-industrial by-product obtained after shea butter extraction. It is a colossal waste and constituting health problem to community where the industry is located because of its abundance. The results of the blood profile of the experimental animals indicated its safe consumption up to the 20% inclusion level.

© 2018 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license..

groups. Since the parameters measured were within the normal range for goats' blood profile, hence, SNC does not have any deleterious effect on the health of the animals. It was concluded that SNC could be incorporated into the diet of goats up to 20% without posing health hazard on the animals.

Subjects: Agriculture & Environmental Sciences; Plant & Animal Ecology; Food Additives & Ingredients

Keywords: blood; haematology; serum; shea nut cake; West African dwarf (WAD) goats

1. Introduction

Goats play an important socio-economic role in the rural areas where most of the peasant farmers live (Anaeto, Tayo, Chioma, Ajao, & Peters, 2009) and form an integral part of the cultural life and system of Nigeria's peasantry (Ajala, 2004). The role played by ruminants in improving the low animal protein intake by Nigerian and other developing countries cannot be over emphasized. Notwithstanding the importance of goats, its production is still hindered as a result of shortage of feed both in quantity and quality at some seasons of the year. Quality forage, which could have alleviated the problem of feed scarcity, declines during rainy season and convectional feedstuff such as grains and oil seeds which are available during this period are very expensive to be used as feed for ruminants.

The challenges of availability and affordability of feeds have therefore push scientists to find alternative sources of feeds that are sustainable and are not consumed by human beings. Shea nut cake (SNC), which is an oilseed by-product, has been identified as one of such alternatives. Increasing world demand for shea butter as a cocoa butter substitute, as well as for cosmetics (Hall, Aebischer, Tomlinson, Osei-Amaning, & Hindle, 1996; Hatskevich, Jenicek, & Antwi Darkwah, 2011) has increased the production of SNC as the by-product in sub-Saharan Africa. In Nigeria, the livestock feed industry is heavily dependent on, among others, oilseed resources such as groundnut cake, soybean cake, cotton seed cake and palm kernel meal (RMRDC, 2003).

Shea butter tree, *Vitellaria paradoxa* is one of the key agro forestry species in Africa. It covers a 500–700-km wide and 5000-km long stretch of African savanna from Senegal to Ethiopia and Uganda (Umali & Nikiema, 2002). In Nigeria, the major area of occurrence is the Guinea and Sudan savanna zones (Keay, 1989). On the global scale, the species has made remarkable contributions in the food and cosmetic industries because of its seed fat extract known as shea butter (Boffa, Yameogo, Nikiema, & Taonda, 1996). Locally, shea butter tree is invaluable in traditional medicine, provision of fuel wood and in the production of soap, candle and pomade (Awoleye, 1995). Its dietary importance at the local level is derived from the fat extract which is used for cooking as well as the fruit pulp which is consumed by humans and livestock (ICRAF, 2000). The protein-rich caterpillars of *Cirina butyrospermi* associated with the species are commonly found as a good delicacy among the Yoruba and Nupe (Ande, 2004) as well as the Tiv ethnic groups in Nigeria (Ugese, Ojo, & Bello, 2005). Although the seed fat extract of shea seed has helped to bring the crop to global limelight, not much seems to be known of the seed cake, a by-product of fat extraction being utilized by ruminants in Nigeria. The upsurge in the use of oilseeds and grains such as soybean, maize and wheat for biofuel is already taking its toll on global food security (Spore, 2008). It has therefore become imperative to explore other alternatives for the feed industry to alleviate the current poor food supply situation. Exploring the nutritional content of SNC in Nigeria, the world's leading producer of shea nuts (Umali & Nikiema, 2002; Umobong, 2006) and its utilization by ruminant animals will be a step in the right direction.

Nutritional studies should not be only focusing on the performance and intake by the said animals, as the effect of such feed on blood constituents of livestock is also very germane. Jackson and Cockcroft (2002) stated that clinical examination is necessary to identify the clinical

abnormalities that are present and the risk factors that determine the occurrence of the disease in the individual or population. He went further to say that without a proficient clinical examination and an accurate diagnosis it is unlikely that the control, prognosis and welfare of animals will be optimized. Aderinboye, Onwuka, Aina, and Oduguwa (2009) further affirmed that blood examination is a good way of assessing the health status of animals as it plays a vital role in the physiological, nutritional and pathological status of animals. According to Animashaun, Omoikhoje, and Bamgbose (2006) and Ojebiyi et al. (2007), the use of haematological studies is very important in considering the health status of animals used in various feed trials. Olorode and Longe (1999) have reiterated that nutrition interferes with the metabolites and other constituents found in the blood. Haematology and serum biochemistry facilitates diagnosis of a disease condition enhances prognosis and assessment of efficacy of therapy and toxicity of drugs and substances (Fajemisin & Adeleye, 2005). However, Benjamin (1981) also mentioned that laboratory study and tests on blood profile were important tools to detect any deviation from normal animal or human body.

However, the sourcing for safe, readily and locally available feed ingredients to enhance food production prompted this research which aimed at assessing the impact of SNC diets on the blood profiles of West African dwarf goats.

2. Materials and methods

2.1. Site of the study

The experiment was conducted at the goat unit of Teaching and Research Farm of the College of Agriculture, Kwara State University, Malete, Nigeria.

2.2. Experimental design and diets

Twelve (12) growing West African dwarf male goats weighing between 7 and 11 kg, obtained from a local market were allotted into three treatments in a completely randomized design with four animals per treatment. The diets were compounded to include SNC at 0% (T1), 10% (T2), and 20% (T3) (Table 1). Other ingredients in the diets were corn bran, cassava peel, cowpea husk and wheat bran. SNC was obtained from a local shea butter processing factory in Ilorin South Local Government Area, Kwara State, Nigeria. The SNC was sun dried for 4 days, ground into smaller particles before mixing with other feedstuffs.

2.3. Management of animals

The goats were treated against ecto- and endo-parasite with Ivomec injection, anthelmintic drug (Albendazole) and oxytetracycline (broad spectrum antibiotics). The animals were weighed and allotted to different diets. Water was given *ad libitum* daily. The diets were offered to the animals daily at 8.00 and 16.00 hrs. During the 84-day experimental period, quantities of feeds offered and that refused were measured daily to compute feed intake while weight changes of the goats were recorded weekly.

Table 1. Composition of experimental diets

	Diets		
Ingredients (%)	**T1 (Control, 0% SNC)**	**T2 (10% SNC))**	**T3 (20% SNC)**
Shea nut cake (SNC)	0	10.0	20.0
Cassava peels	25	22.5	20.0
Corn bran	25	22.5	20.0
Cowpea husk	25	22.5	20.0
Wheat bran	25	22.5	20.0
Total	100	100	100

2.4. Haematological and serum analysis

Blood samples were collected from each goat by the jugular venipuncture at the end of the feeding trial. The animals were bled in the morning prior to feeding and average of 5 ml blood was collected from each goat. The blood samples were transferred immediately into sterile sampled bottles containing ethylene diamine-tetra-acetic acid which was used for the haematological analysis and another 5 ml into the non-heparinised bottle for serum analysis. Haematological analysis of packed cell volume (PCV), haemoglobin (Hb), red blood cell (RBC), the mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), total white blood cell (WBC) and the differential counts were measured as described by Jain (1986) and various serum biochemistry such as total protein (TP), albumin serum cholesterol, aspartate aminotransferase (AST), alanine amino transferase (ALT) were determined using methods of Jain (1986).

2.5. Statistical analysis

Data obtained were subjected to analysis of variance to determine the significant of treatment effects following the methods described by SAS (2010). Significant differences between means were compared using the Duncan New Multiple Range test of the same package at 5% level of probability.

3. Results and discussion

Table 2 gives the chemical composition of the experimental diets prepared from different levels of SNC inclusion. Crude protein (CP) concentration of the formulated diets decreased as the SNC level increased. However, these values were within the range of CP concentration that could be sufficient for microbial activities in the rumen because it is higher than the minimum level of 7–8% dry matter (DM) required for optimum rumen function and feed intake in ruminant livestock (Van Soest, 1994). According to Paterson, Cohran, and Klopfenstein (1996), feedstuffs with a CP content lower than 70 mg g^{-1} DM require a supplementation of nitrogen to improve their ingestion and digestion by the ruminants. It is an indication that the formulated diets could be a good supplement to poor forage.

The haematological indices (Table 3) of goats fed experiment diets. In the present study, there were slight significant differences ($p < 0.05$) on the blood profile of the animals after the introduction of the experimental diets. The Hb content ranged from 8.30 (T2 and T3) to 9.88 g/dl (T1) among the treatment groups. This is within the normal ranges of 8.0–15.0 g/dl reported for normal blood functions by Blood, Studdert, & Gay (2007) and Daramola, Adeloye, Fatoba, and Soladoye (2005). The Hb values showed that the experimental diets were adequate for the nutritional requirements, and the test diets did not pose any danger to the animals. The aim of estimating the Hb content is to assess the oxygen carrying capacity of

Table 2. Chemical composition of the experimental diets (%)

Parameters	T1 (0%)	T2 (10%)	T3 (20%)	SEM
DM	92.42^{b}	93.03^{a}	92.90^{ab}	0.14
CP	11.37^{a}	9.84^{b}	9.18^{b}	0.33
EE	2.03^{b}	2.79^{a}	2.19^{b}	0.09
CF	17.20^{b}	16.84^{b}	19.54^{a}	0.20
ASH	9.63^{b}	11.24^{ab}	12.11^{a}	0.54
NDF	30.69^{b}	48.51^{a}	48.51^{a}	0.33
ADF	21.56^{c}	41.17^{a}	32.35^{b}	0.34
ADL	12.35^{a}	8.96^{b}	9.73^{b}	0.47

a,b,c = means within the same row with different superscripts are significantly different (P < 0.05).

SEM = Standard error of mean, DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre, NDF = Nuetral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin.

Table 3. Haematological parameters of experimental animals fed graded level of SNC

Parameters	T1 (0%)	T2 (10%)	T3 (20%)	SEM
Haemoglobin (g/dl)	8.33	8.33	9.88	1.41
PVC (%)	20.59	22.05	21.97	0.53
RBC ($\times 10^6$/µl)	6.51^b	7.06^a	6.82^b	0.73
WBC ($\times 10^9$/l)	8.46^b	12.75^a	9.29^b	1.56
MCV (fl)	21.83	22.17	22.12	0.77
MCH (pg)	7.58	8.23	8.50	0.39
MCHC (%)	33.00^b	34.73^a	33.90^b	1.93
Lymphocytes (%)	51.27	51.85	53.78	1.27

Note: a,b,c = means within the same row with different superscripts are significantly different ($p < 0.05$), SEM: standard error of mean; PVC: packed cell volume; RBC: red blood cell; MCV: mean corpuscular volume (fl); MCH: mean corpuscular haemoglobin, MCHC: mean corpuscular haemoglobin concentration.

the goat circulatory system. Having a low oxygen carrying capacity indicates that such animal can easily succumb to stress factors that may lead to respiratory problems, while those with high level of Hb content can be regarded as having high level of oxygen capacity and therefore, likely to withstand respiratory stress (Oni et al., 2012). PCV concentrations were not significantly different ($p > 0.05$) among the treatment groups. The PCV is the measure of the ratio of the volume occupied by the RBCs to the volume of the whole blood in a sample of capillary or arterial blood. The PCV ranged between 20.50% and 22.05%. These were however, within the value reported elsewhere (Daramola et al., 2005; Swati & Varsha, 2014). The results of the analysis showed that PCV values were within the normal range for goat (Jain, 1993). The low PCV values in the study could be as a result of the breed and locations at which the animals were sourced from Jackson and Cockroft (2002) and Opara, Udevi, and Okoli (2010). RBC counts ranged from 6.82–7.06 × 10^6/µl. This is within the normal range of 5–10 × 10^6/µl (Blood et al., 2007; Daramola et al., 2005). Since it is the RBCs that carry the respiratory pigments (Hb), a decrease in the quantity of the circulating RBC implies a decrease in the quantity of Hb and thus decreases in the oxygen carrying capacity of the animal. RBC among treatment effects was not significantly ($p > 0.05$) difference between diets T1 (6.51 × 10^6/µl) and T3 (6.82 × 10^6/µl) but diet T2 (7.06 × 10^6/µl) was significantly ($p < 0.05$) higher than diets T1 and T3. The highest RBC (numerically but not significant statistically) recorded in diet T2 corresponded with the high values of PCV concentration observed in diets T2 and T3, suggesting their superiority in terms of their capability of supporting high oxygen carrying capacity of the blood and absence of anaemia-related diseases which might be due to iron deficiency. The values of RBC were comparable to the reported range of 7.38–13.62 × 10^{12}/l for West African goat by Aina and Akinsoyinu (1996). It also falls within the range reported by Aruwayo et al. (2011). The WBC plays a prominent role in disease resistance especially with respect to the generation of antibodies. WBC was significantly ($p < 0.05$) highest in diet T2 (12.75 × 10^6/µl) and lowest in diet T1 and T3 (8.46–9.29 × 10^6/µl respectively). The WBC counts were higher than the value (5 × 10^6/dl to 11 × 10^6/dl) reported by Scott, Ketheesan, and Summers (2006) for sheep but within the level reported for WAD goats (Daramola et al., 2005). This implies that goats on the diets remained clinically healthy as indicated by researchers (Konlan, Karikari, & Ansah, 2012) and that the animals will be able to fight against any foreign body in the circulatory system . The foreign bodies are likely to be pathogens that have built up due to compositional changes that occurred during the slow drying process which would have allowed build-up of microorganisms which may be pathogenic in nature.

The MCV and MCH values obtained in this study did not vary significantly ($p > 0.05$) among the animals fed experimental diets. The values ranged between 21.83 and 22.18 fl and 7.58–8.50 pg,

respectively. The MCV are indications of macrocytic (regenerative) anaemia emanating from increased destruction and subsequent enhanced erythropoiesis in the liver, spleen and kidneys (Jain, 1986). The mean corpuscular volume (MCV) and the higher MCH values recorded in the present study compared well with the values reported elsewhere (Mitruka & Rawnsley, 1977). The MCHC of animals fed T2 and T3 diets were not significantly ($p > 0.05$) different from the value of control group. The concentrations obtained across the treatments for MCHC were within the 30.0–34.4% reported (Mitruka & Rawnsley, 1977) for clinically healthy animal. The MCHC values have been reported to be the most accurate and absolute values that indicate anaemic condition in animals (Ogbuewu, Uchegbu, Okoli, & Iloeje, 2010; Thompson, 2006). Lymphocytes use the blood to travel round the body but can wander freely in other types of tissues using the lymphatic channels. The lymphocytes also known to play key roles in the immune defence system as a function of the immune status. An increase in lymphocytes number is in response to viral, parasitic and bacterial infection of the animal's body (Coles, 1980). The concentrations of lymphocytes were not significantly different but the concentration in the group of animals fed SNC at 20% was the highest. However, the values reported in this study were at variance with the values reported elsewhere (Tambuwal, Agale, & Bangana, 2002) but fell between the values (49–53%) reported by Belewu and Ojo-Alokomaro (2007) for normal blood profile of WAD goats.

Table 4 shows the serum biochemical parameters of WAD goats fed experimental diets. Serum parameters have been reported to be important in the proper maintenance of the osmotic pressure between the circulating fluid and the fluid in the tissue space so that the exchange of materials between the blood and cell could be facilitated (Isidahomen, Njidda, & Olatunji, 2012). Ikhimioya and Imasuen (2007) also found that serum proteins are important in osmotic regulation, immunity and transport of several substances in the body. Harper et al. (1971) also reported that serum biochemical analysis is used to evaluate the level of heart attack, liver damage and to estimate protein quality and amino acid requirements in animals. The concentrations for serum transaminases (ALT and AST) in the blood are reliable tests for liver damage. Therefore, the values obtained for AST, which is an indication of normal functioning of the liver, were not significantly ($p > 0.05$) different among the groups of animals fed the experimental diets. The concentrations of ALT varied significantly ranging from 9.90 to 12.95 u/l with T2 having the highest concentration. Nonetheless, the values were within the range of the normal animal blood indices (Olafadehan, 2011). This shows that the diets supported the health status of the animals. The value obtained for TPs of all the treatments were not significantly ($p > 0.05$) different from each other. There was no significant difference in the value of cholesterol among the animals under treatments. The cholesterol levels were normal, indicating that the meat from the experimental animals was safe, and would not lead to cholesterol elevation in consumers. Esonu et al. (2001) and Igwebuike, Anugwa, Raji, Ehiobu, and Ikurior (2008) reported that cholesterol in the serum is associated with the quantity and quality of protein supplied in the diet. It is therefore indicated that the protein provided by the SNC combined was enough and of good quality to meet the nutritional needs of the animals. The albumin range of 26.33–32.54 g/l was similar to 29.30–32.70 g/l reported by Babayemi, Bamikole, and Odunguwa (2003) and Oloche, Ayoade, and Oluremi (2015). Albumin which is a

Table 4. Blood serum chemistry of West African dwarf goats fed various levels of SNC diets

Parameters	T1 (0%)	T2 (10%)	T3 (20%)	SEM
AST u/l	55.17	59.95	60.38	1.45
ALT u/l	9.90^{b}	12.95^{a}	11.95^{a}	0.34
TP g/dl	59.93	59.95	60.38	1.45
Cholesterol (mg/dl)	0.69^{b}	1.72^{a}	0.60^{b}	0.04
Albumin g/dl	26.33^{b}	30.47^{ab}	32.54^{a}	0.19

Note: a,b,c = means with different superscripts on the same row are significantly different ($p < 0.05$), SEM: standard error of mean; AST: aspartate aminotransferase; ALT: alanine amino transferase; TP: total protein.

very good indicator of health was observed to be normal in this present study. In the current study, the experimental goats did not show clinical signs of ill health or of any toxicity, such as head pressing, generalized depression, grinding teeth, foaming at the mouth and twitching and jerking (Odenyo, Osuji, Karanfil, & Adinew, 1997).

4. Conclusion

In conclusion, addition of the SNC up to 20% will not pose any health problem to the animals since the parameters measured in the blood of the animals under the study conditions, were within normal blood range for a healthy animal. This therefore suggests SNC to be a good feedstuff for ruminant animals to mitigate dry season feed shortage due to its abundant and availability all the year round.

Funding
The authors received no direct funding for this research.

Competing interests
The authors declare no competing interests.

Author details
Dupe Olufunke Ogunbosoye[1]
E-mail: dupe.ogunbosoye@kwasu.edu.ng
ORCID ID: http://orcid.org/0000-0002-9349-1536
Abayomi Akinfemi[2]
E-mail: akinfemiabayomi@gmail.com
David Aderemi Ajayi[3]
E-mail: rhemiajayi@gmail.com
Pedro González-RedondoReviewing Editor
[1] Department of Animal Production, Fisheries and Aquaculture, Kwara State University, Malete, Nigeria.
[2] Department of Agricultural Technology, Yaba College of Technology, Yaba Lagos, Nigeria.
[3] Department of Animal Genetic Resources, National Centre for Genetic Resources and Biotechnology, Moor Plantation, Ibadan, Nigeria.

Citation information
Cite this article as: Blood profiles of West African dwarf (WAD) growing bucks fed varying levels of shea nut cake based rations in Nigeria, Dupe Olufunke Ogunbosoye, Abayomi Akinfemi & David Aderemi Ajayi, *Cogent Food & Agriculture* (2018), 4: 1474620.

References

Aderinboye, R. Y., Onwuka, C. F. I., Aina, A. B. J., & Oduguwa, O. O. (2009). Effect of dietary monensin inclusion on selected haematogical parameters in West African dwarf goats. Proc. 14th Ann. *Conference of the Animal Science Association of Nigeria* (ASAN) (pp. 619–621). Sept. 14th–17th 2009. Nigeria: LAUTECH Ogbomosho.

Aina, A. B. J., & Akinsoyinu, A. O. (1996). Effect of dietary copper supplementation on serum copper level and performance of female West African dwarf goats. *Nigerian Journal of Animal Production*, *23*(1), 61–65.

Ajala, M. K. (2004). Household decision-making in the production of small ruminants in Giwa local government area of Kaduna State of Nigeria. In: *Proceedings of the 29th annual conference of the Nigerian Society for Animal Production* (pp 309–402). Sokoto, Nigeria: Usman Danfodio University.

Anaeto, M., Tayo, G. O., Chioma, G. O., Ajao, A. O., & Peters, T. A. (2009). Health and nutrition practices among smallholder sheep and goat farmers in Ogun State Nigeria. *Livestock Research for Rural Development*, *21*, 11.

Ande, A. T. (2004). The pupal habits of Cirina forda, a leading food insect in Kwara state, Nigeria. *Journal of Sustainable Tropical Agricultural Research*, *9*, 97–100.

Animashaun, R. A., Omoikhoje, S. O., & Bamgbose, A. M. (2006). Hematological and biochemical indices of weaner rabbit fed concentrate and Syndrella multliflora forage supplement. *Proceeding of 11th annual conference of Animal Science Association of Nigeria (ASAN)*. Ibadan, Nigeria, pp 29–31.

Aruwayo, S.A, & Maigandi, B.S. (2011). *Haematological and Biochemical Parameters Of Uda Lambs Fed Graded Levels Of Alkali -Treated Neem Kernel Cake*, *19*(2), 277-284.

Awoleye, F. (1995). Effects of seed sources on the growth of seedlings of *Vitellaria paradoxa* in the Southern Guinea Savannah of Nigeria. *Nigerian Journal of Botany*, *8*, 65–69.

Babayemi, O. J., Bamikole, M. A., & Odunguwa, B. O. (2003). Haematological and biochemical components of West African dwarf goats fed *Tephrosia bracteolata*–based forage. *Tropical Journal of Animal Investigation*, *6*, 31–38.

Belewu, M. A., & Ojo-Alokomaro, K. O. (2007). Hematological indices of West African dwarf goat fed leaf meal based diets. *Bulgaria Journal of Agricultural Science*, *13*, 601–606.

Benjamin, M. M. (1981). *Outline of veterinary clinical pathology* (3rd ed., pp. 5–162). Ames, IOWA, U.S.A: The IOWA state University Press.

Blood, D. C., Studdert, V. P., & Gay, C. C. (2007). *Saunders comprehensive veterinary dictionary* (3rd ed.). Oxford: Elsevier.

Boffa, J. M., Yameogo, G., Nikiema, P., & Taonda, J. B. (1996). What future for the shea tree?. *Agroforestry Today (ICRAF)*.

Coles, E. H. (1980). *Veterinary clinical pathology* (3rd ed., pp. 10–20). Philadelphia: W. B. Sanders and Co.

Daramola, J. O., Adeloye, A. A., Fatoba, T. A., & Soladoye, A. O. (2005). Haematological and biochemical parameters of West African Dwarf goats. Livestock Research for Rural Development, 17(8), p.3.

Esonu, B. O., Emenalon, O. O., Udedibie, A. B. I., Herbert, U., Ekpor, C. F., Okoli, I. C., & Ihekwumere, F. C. (2001). Performance and blood chemistry of weaner pig fed raw Mucuna (Velvet bean) meal. *Tropical Animal Production Investigation.*, *4*, 49–54.

Fajemisin, A. N., & Adeleye, I. O. A. (2005). Time related qualitative changes in the haematological values of rat blood kept at room temperature. *Proceeding of 30th annual conference Nigerian Society for Animal Production*, *30*, 41–44.

Hall, J., Aebischer, D., Tomlinson, H., Osei-Amaning, E., & Hindle, J. (1996). *Vitellaria paradoxa: A monograph* (pp. 105–107). Banghor: School of Agricultural and Forest Sciences, University of Wales.

Harper, H. (1971). Review of physiological chemistry. FAO, UN.

Hatskevich, A., Jenicek, V., & Antwi Darkwah, S. (2011). Shea industry – A means of poverty reduction in northern Ghana. *Agricultura Tropica and Subtropica*, *44*, 223–228.

ICRAF. (2000). International Centre for Research in Agroforestry. *Agroforestry*, *13*, 75–100.

Igwebuike, J. U., Anugwa, F. O. I., Raji, A. O., Ehiobu, N. G., & Ikurior, S. A. (2008). Nutrient digestibility, hematological and serum biochemical indices of rabbits fed graded levels of Acacia albida pods. *Journal of Agricultural and Biological Science*, *3*(4), 33–39.

Ikhimioya, I., & Imasuen, J. A. (2007). Blood profile of West African dwarf goats fed *Panicum maximum* supplemented with *Afzelia africana* and. *Newbouldia Laevis. Pakistan Journal of Nutrition*, *6*(1), 79–84. doi:10.3923/pjn.2007.79.84

Isidahomen, C. E., Njidda, A. A., & Olatunji, E. A. (2012). Heat tolerant traits among local and exotic chickens in southern Nigeria (2012). *IOSR. Journal of Agriculture and Veterinary. Science*, *1*(6), 31–36. doi:10.9790/2380-0163136

Jackson, P. G. G., & Cockcroft, P. D. (2002). *Clinical examination of farm animals by Blackwell Science Ltd, a Blackwell Publishing Company Editorial Offices*. Osney Mead, Oxford OX2 0EL, UK.

Jain, N. C. (1986). *Schalm's veterinary hematology* (4th. pp. 20–86). N. C. Jain (Ed). Philadelphia: Lea & Febiger.

Jain, N. C. (1993). Essentials of Veterinary Haematology. Lea and Ferbeigner, Pennsylvania, U.S.A. pp 7.

Keay, R. W. J. (1989). *Trees of Nigeria* (pp. 476). Oxford: Clarendon Press.

Konlan, S. P., Karikari, P. K., & Ansah, T. (2012). Productive and blood indices of dwarf rams fed a mixture of rice straw and groundnut haulms alone or supplemented with concentrates containing different levels of shea nut cake. *Pakistan Journal of Nutrition*, *11*(6), 566–571. Letchworth, Hertfordshire, UK. doi:10.3923/pjn.2012.566.571

Mitruka, B. M., & Rawnsley, H. M. (1977). *Clinical biochemical and haematological reference values in normal experimental animals. 65 p. Masson Publ. Co., New York, USA*.

Odenyo, A. A., Osuji, P. O., Karanfil, O., & Adinew, K. (1997). Microbiological evaluation of Acacia angustissima as a protein supplement for sheep. *Animal Feed Science Technology*, *65*, 99–112. doi:10.1016/S0377-8401(96)01087-5

Ogbuewu, I. P., Uchegbu, M. C., Okoli, I. C., & Iloeje, M. U. (2010). Assessment of blood chemistry, weight gain and linear body measurements of pre-puberal buck rabbits fed different levels of neem (*Azadirachta indica* A. Juss.) leaf meals. *Chilean Journal of Agricultural Research*, *70*(3), 515–520. doi:10.4067/S0718-58392010000300020

Ojebiyi, O. O., Farina, G. O., Togun, V. A., Aderinbola, O. A., Olayemi, T. B., & Moronfolu, O. O. (2007). Study on growth and haematological attribute of weaner rabbit ted graded level of Sun dried Cassava peel, blood meal mixture. *Proceeding of the 32nd annual conference of the Nigerian Society for Animal Production*, 18–21th March, 2007. Calabar, Nigeria.

Olafadehan, O. A. (2011). Changes in haematological and biochemical diagnostic parameters of red Sokoto goats fed tannin-rich *Plerocarpus erinaceus* forage diets. *Veterinarski Archv*, *81*(4), 471–483.

Oloche, J., Ayoade, J. A., & Oluremi, I. A. (2015). Haematological and serum biochemical characteristics of West African dwarf goats fed complete diets containing graded levels of sweet orange peel meal. *American Journal of Experimental Agriculture*, *9*(1), 1–5. doi:10.9734/AJEA/2015/11313

Olorode, B. R., & Longe, O. G. (1999). Growth, nutrient retention, haematology and serum chemistry of pullet chicks fed shea butter cake in the humid tropics. *Archivos De Zootecnia*, *49*(187), 444.

Oni, A. O., Arigbede, M. O., Sowande, O. S., Anele, U. Y., Oni, O. O., Onwuka, C. F. I., … Aderinboye, R. K. (2012). Haematological and serum biochemical parameters of West African dwarf goats fed dried cassava leaves-based concentrate diets. *Tropical Animal Health Production*, *44*, 483–490. doi:10.1007/s11250-011-9923-0

Opara, M. N., Udevi, N., & Okoli, I. C. (2010). Haematological parameters and blood chemistry of apparent healthy West African dwarf (WAD) goat in Owerri, South Eastern Nigeria. *New York Science Journal*, *3*(8), 68–72.

Paterson, J., Cohran, R., & Klopfenstein, T. (1996). Degradable and undegradable protein response of cattle consuming forage based diets. Proc 3rd Grazing Livestock Nutrition Conference (Iudkins MB, Mc Collum III FT, eds.). *Proceeding West Second American Society of Animal Science*, *47*(Supplementary 1), 94–103.

RMRDC. (2003). Raw Materials Research and Development Council. *Multi-disciplinary committee report of a techno-economic survey on beverage and tobacco sector*, Abuja, Nigeria, 31.

SAS. (2010). *Statistical analysis system. SAS/STAT users' guide*. Version 8. Cary, NC: Author.

Scott, J. L., Ketheesan, N., & Summers, P. M. (2006). Leucocyte population changes in the reproductive tract of the ewe in response to insemination. *Reproduction Fertility and Development*, *18*, 627–634. doi:10.1071/RD05165

Spore. (2008, April). *Food products soaring prices*. Spore No 134.

Swati, R. D., & Varsha, D. J. (2014). Haematological parameters of Indian goats feddried *Clitoria* leaves based diets. *European Journal of Experimental Biology*, *4*(4), 73–77.

Tambuwal, F. M., Agale, B. M., & Bangana, A. (2002). Haematological and biochemical values of apparently healthy Red Sokoto goats. *Proceeding of the 27th annual conference, Nigerian Society of Animal Production held at FUTA*, Nigeria, pp: 50–53.

Thompson, R. B. (2006). *A short textbook of hematology* (7th ed., pp. 217 p). Garden City Press Ltd. Letchworth, Hertfordshire, UK.

Ugese, F. D., Ojo, A. A., & Bello, L. L. (2005). Effect of presowing treatment and nut orientation on emergence and seedling growth of seeds of shea butter tree (Vitellaria paradoxa). *Nigerian Journal of Botany*, *18*, 294–304.

Umali, B. E., & Nikiema, A. (2002). *Vitellaria paradoxa C. F. Gaertn. Record from protabase*. L.P.A Oyen & R.H.M.J. Lemmens (Eds.). Wageningen, the Netherlands: PROTA.

Umobong, E. A. (2006). How to profit from the massive shea butter export boom! *Success Digest*, February, 8-11.

Van Soest, P. J. (1994). *Nutritional ecology of the ruminant*. Ithaca, NY: Cornell Univ Press.

© 2018 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:
Share — copy and redistribute the material in any medium or format.
Adapt — remix, transform, and build upon the material for any purpose, even commercially.
The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:
Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.
You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.
No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

Cogent Food & Agriculture **(ISSN: 2331-1932) is published by Cogent OA, part of Taylor & Francis Group.**

Publishing with Cogent OA ensures:

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com