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Response of Sheep to Dietary Soybean Haulms: Effect on Growth, Serum Indices and Oxidative Biomarkers Profile

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ABSTRACT

Background and Objective: Utilization of crop residue in complete diets of ruminants may be a sustainable alternative for enhanced profitability in production. This research assessed the performance of sheep-fed dietary soybean haulms in a complete diet with or without garlic powder. **Materials and Methods:** Sixteen rams were divided into three treatment groups in a completely randomized design and assigned to three treatment diets as follows: Control (no soybean haulms inclusion), SHD (30% inclusion of soybean haulms) and SHGD (30% inclusion of soybean haulms+0.5% inclusion of garlic). The animals were managed on experimental diets for 77 days. Data collected on feed intake, weight changes, feed conversion ratio, hematological parameters and serum indices were subject to one-way analysis of variance using the GLM procedure of SPSS (version 23). **Results:** It indicated that weight changes, feed intake and FCR were not affected ($p>0.05$) by feeding 30% soybean haulms to sheep in complete diets with or without garlic powder. However, total protein, packed cell volume, hemoglobin, MCV, MCH and uric acid were reduced in the treatment group fed soybean haulms. The addition of garlic in a soybean haulms-based diet did not influence ($p>0.05$) the effects observed by the inclusion of soybean haulms. All other hematological parameters, blood metabolites and oxidative biomarkers were not affected ($p>0.05$) by the addition of soybean haulms in the complete diet of sheep. **Conclusion:** As 30% soybean haulms can be included in the complete diet of sheep as alternative feedstuff. Including soybean, haulms may also improve the animal's antioxidant capacity by reducing uric acid.

KEYWORDS

Sheep, soybean haulms, garlic powder, performance, physiology, oxidative stress

INTRODUCTION

There has been a continued search for cheap alternative sources of feed ingredients other than feeding human-edible materials to animals and the use of arable land to produce animal feed instead of producing human-edible food directly for sustainable ruminant production[1]. This calls for concerted efforts towards identifying feed ingredients with less competition with man and monogastric animals that are also readily available in commercial quantities. Crop residues remain available as cheap alternative sources

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because they are left to waste on farms without further processing. During feed scarcity, especially in dry seasons, crop residue forms a significant part of the maintenance diet for livestock. The residues may be obtained at no cost from most smallholder farms after crop harvest or can be gotten at very little cost[2]. Using crop residues in animal diets could also address the problem associated with burning them on the farm, constituting environmental hazards. Also, using crop residues in livestock feed will improve the products along the value chain of the individual crops. One available crop residue that could be explored in the nutrition of ruminants is the soybean haulms.

Soybean haulms consist of the husks of the pods with leaves and tender stems remaining as by-products after harvesting the seeds of pulses[3]. Soybean haulms are an abundant and renewable form of biomass with enormous potential as a low-cost feed and a sustainable source of energy[4]. While the availability of the haulms is promising, their utilization by ruminants may be challenged due to the poor nature of crop residues. Unlike other feedstuff available for ruminant production, crop residues usually has low crude protein, energy and micronutrients with high cell wall constituents like lignin and silica[5]. This makes them less palatable, hence, the characteristic low voluntary intake by animals and low digestibility. All these have limited their use in ruminant feeding regimes. Given the preceding, processing and strategic combination of soybean haulms in a complete diet may improve its quality and utilization in the diets of ruminants[6]. A feeding system that combines soybean haulms and other feedstuff to form a concentrate may be a useful strategy for utilizing crop residue in feeds due to its fibrous nature. Such a strategy will increase intake and improve feed utilization and subsequently, animal production performance. This strategy could also employ feed additives with the potential to modulate the rumen environment for efficient performance. Hence, efforts to assist the animals in utilizing these low-grade feedstuffs more efficiently are key to economically enhancing livestock productivity.

Garlic may help improve the efficiency of nutrient utilization in ruminants. This is because garlic and its products have been reported to modulate rumen fermentation for improved utilization of feed[7]. Garlic supplements reduced CP degradability and increased the total VFAs[7]. These results suggest that the supplementation of garlic product would be the best in improving propionate production and reducing NH_3-N and acetate to propionate ratio. It is important to note that these strategies in improving the utilization of soybean haulms as ruminant feedstuff should ensure improved performance, physiology and oxidative status of the animals, hence, the study was designed to assess the growth performance, hematological parameters, serum indices, blood minerals and oxidative biomarkers of sheep fed complete concentrate diets containing soybean haulms and garlic powder.

MATERIALS AND METHODS

Experimental site: The study was conducted at the Animal Science Teaching and Research Farm of Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria. Makurdi is in the Guinea Savannah zone of Nigeria and GPS coordinates as reported in Ikyume *et al*.[8]. The area is characterized by about 6-7 months of rainy season ranging from 1317-1323 mm annually, between April to October and five months of the dry season (November-March). The temperature ranges from 21.70-34.50°C and it is highest in February and March[9]. The experiment lasted from January to May, 2022, performance records were collected for 77 days between February and May, 2022.

Collection and processing of experimental materials: Coarse forms of soybean haulms were collected from fields around the Animal Science Teaching and Research Farm, Joseph Sarwuan Tarka University, Makurdi. The prominent fibrous stalks were removed and the haulms were milled into a finely coarse form using a hammer machine. The resultant product was then used in a complete diet to formulate the experimental diet. Garlic powder was purchased from an open market in Makurdi, Benue State.

Table 1: Composition of experimental diets

Ingredient	Control	SHD	SHGD
Maize offal	55.00	35.0	35.0
Soybean meal	15.00	10.0	10.0
Palm kernel cake	25.00	20.0	25.0
Soybean haulms	-	30.0	30.0
Bone meal	3.00	3.0	3.0
Salt	1.00	1.0	1.0
Vitamin/mineral premix	1.00	1.0	1.0
Total	100.00	100.0	100.0
Garlic powder	-	-	0.5
Determined analysis			
Dry matter	84.09	87.01	86.56
Crude protein	16.58	14.12	14.96
Ash	7.68	6.95	7.34
Ether extract	17.20	18.19	18.94
NDF	47.23	48.23	49.10
ADF	38.96	39.32	38.99

Control: No soybean haulms inclusion, SHD: 30% inclusion of soyabean haulms and SHGD: 30% inclusion of soyabean haulms+0.5% inclusion of garlic

Experimental animal, design and dietary treatments: A total of fifteen rams used for the study were purchased from the open market in Lafia, Nasarawa State, Nigeria. The experimental design was a completely randomized design with three diets formulated as follows: Control (no soybean haulms inclusion), SHD (30% inclusion of soybean haulms) and SHGD (30% inclusion of soybean haulms+0.5% inclusion of garlic) as shown in Table 1. All animals on arrival were quarantined for 6 weeks before the commencement of the experiment. The animals were treated for possible bacterial infection using PenStrep® (1 mL/10 kg). They were also treated for ecto and endo parasites using Ivermectin® (0.5 mL/10 kg), subcutaneously. Before the arrival of the animals, the pen was thoroughly cleaned and disinfected using izal® solution. The rams were housed in separate pens measuring 1×1.5 m each. The house was constructed to have a free flow of air. The pen floor was slated and made of wood, the walls were also made of wood with a zinc roof. The experimental animals were fed concentrate diets (Experimental diets) and forage (Panicum maximum) in the morning and afternoon (7:00 am and 12:00 pm), respectively and fresh, clean water was provided *ad libitum*. The animals were maintained under hygienic conditions and were confined throughout the experimental period. The experiment was approved by the Ethical Committee of the College of Animal Science, Joseph Sarwuan Tarka University, Makurdi (ethical number: JOSTUM/ANS/ANP/2020/2021).

Data collection

Feed intake, weight changes and feed conversion ratio: The initial body weight of the rams was taken at the commencement of the experiment using a digital weighing scale (Model: SCS-AS14, Manufacturers: Changzhou Asia weighing system solution). Weight changes in the animals were determined every week. Forage and concentrate intakes were determined daily. The feed conversion ratio was estimated as the ratio of feed intake and weight gain:

$$\text{Weight change (kg)} = \text{Final weight-Initial weight}$$

$$\text{Feed intake (kg)} = \text{Feed offered-Feed left over}$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed intake}}{\text{Weight gain}}$$

Blood collection and analysis: At the end of the experiment, about 5 mL of blood was collected via the jugular vein of the animals using needles and syringes. After collecting, 2 mL of the blood was emptied into sample bottles containing anticoagulant (EDTA) to prevent clothing for subsequent analysis of haematological parameters. The remaining 3 mL was emptied into sample bottles without anticoagulant. Thereafter, the blood sample was centrifuged and serum harvested for analysis of serum indices, minerals and antioxidant parameters. The parameters measured include: Total protein, albumin, glucose, total cholesterol, triglycerides, lipids, uric acid, MDA, glutathione peroxidase, sodium, potassium, chloride, calcium, packed cell volume, red blood cells, white blood cells etc. Red blood cells, white blood cells and lymphocytes were evaluated with the help of an automatic blood analyser (ADVIA 120, Bayer, USA) according the method described in Stanworth *et al.*[10], while packed cell volume (PCV) was determined as described in Stephen *et al.*[11] using the microhaematocrit method, hemoglobin (Hb) was determined as described in Nkrumah *et al.*[12] using cyanmethemoglobin method. The procedure for plasma glucose concentration determination is mentioned in Abdalla and Abdelatif[13] using a kit (Spinreact, S.A., Spain). Serum triglyceride and cholesterol, LDL and HDL were measured using a biochemical analyzer (Olympus Au 400 system autoanalyzer) according to Babaeenezhad *et al.*[14]. The procedure described in the report of Afele *et al.*[15] was used for the determination of blood minerals and serum antioxidants.

Statistical analysis: The results of growth indices, haematological parameters, serum indices, serum minerals and oxidative biomarkers were analysed using one-way analysis of variance as contained in the general linear models procedures of SPSS (version 23) as described in Ikyume *et al.*[16] with individual sheep serving as the experimental unit. Significant differences among treatment means where applicable were separated at a probability level of 5% ($p \leq 0.05$).

RESULTS

Growth response of sheep to dietary soybean haulms with/without garlic powder: The result of the growth performance of sheep to dietary inclusion of soybean haulms in complete feed was shown in Table 2. All growth indices measured were not affected ($p > 0.05$) by the inclusion of soybean haulms with/without garlic powder in the diet. However, the inclusion of garlic in soybean haulms based diets showed marginal improvement ($p > 0.05$) in growth indicators compared to feeding only soybean haulms. This was as marginal decreases ($p > 0.05$) were observed in growth indices in the soybean haulms based diets compared to the control.

Haematological indices of sheep in response to dietary soybean haulms with/without garlic powder: The result of haematological indices of sheep in response to dietary soybean haulms with/without garlic powder was provided in Table 3. Packed cell volume decreased ($p < 0.05$) in soybean haulms based diets with/without garlic powder (29.00 and 27.75%, respectively) compared to the control diet (38.25%). A similar trend as in packed cell volume was seen in haemoglobin concentration, mean corpuscular volume and mean corpuscular haemoglobin. Haemoglobin was higher ($p < 0.05$) in the control diet (12.75 g dL^{-1}) compared to the other soybean haulms with/without garlic powder based diets (9.68 and 9.25 g dL^{-1} for SHD and SHGD, respectively). Mean corpuscular volume and mean corpuscular haemoglobin values were higher ($p < 0.05$) in the control diet (64.05 fl and 21.33 pg, respectively) compared to the soybean haulms based diets with or without garlic powder. Other haematological indices evaluated were not affected ($p > 0.05$) by the inclusion of soybean haulms with or without garlic powder in the diet.

Serum indices of sheep in response to dietary soybean haulms with/without garlic powder: Table 4 represented the result of serum indices of sheep in response to dietary soybean haulms with/without garlic powder. Total protein concentration in the blood reduced ($p < 0.05$) in the soybean haulms diets with or without garlic powder (5.40 and 5.23 mg dL^{-1}, for SHD and SHGD, respectively). However, the albumin, glucose, cholesterol, triglyceride and lipid profile of the rams were not affected ($p > 0.05$) by the addition of soybean haulms with or without garlic powder in the diet.

Oxidative biomarkers and blood metabolites of sheep fed a complete diet containing soybean haulms with/without garlic powder: The result of oxidative biomarkers and blood metabolites of sheep fed a complete diet containing soybean haulms with/without garlic powder was indicated in Table 5. All oxidative stress biomarkers except uric acid were not affected ($p>0.05$) by the addition of soybean haulms with or without garlic in complete diets of sheep. Uric acid decreased ($p<0.05$) in soybean haulms with/without garlic powder compared to the control. The control diet had a value of 6.85 g mL^{-1} of uric acid while values of 5.75 and 5.68 mg mL^{-1} were observed for SHD and SHGD, respectively. All blood metabolites were not affected ($p>0.05$) by the inclusion of soybean haulms with/without garlic powder in the diet of sheep.

Table 2: Growth response of sheep fed diets containing soybean haulms with/without garlic powder

	Treatment diets			
Parameter	Control	SHD	SHGD	SEM
Initial weight (kg)	11.78	11.58	11.77	0.47
Final weight (kg)	19.56	17.80	18.26	0.43
Daily weight gain (g)	105.14	84.19	87.62	4.87
Concentrate intake (g)	305.42	282.33	288.79	8.97
Forage intake (g)	778.94	806.13	798.32	6.83
Total feed intake (g)	1084.36	1088.46	1087.11	12.53
Feed conversion ratio	10.96	13.11	12.51	0.61

Control: No soybean haulms inclusion, SHD: 30% inclusion of soyabean haulms, SHGD: 30% inclusion of soyabean haulms+0.5% inclusion of garlic and SEM: Standard error of mean

Table 3: Haematological parameters of sheep fed diets containing soybean haulms with/without garlic powder

	Treatment diets			
Parameter	Control	SHD	SHGD	SEM
Packed cell volume (%)	38.25[a]	29.00[b]	27.75[b]	1.76
Haemoglobin (g dL^{-1})	12.75[a]	9.68[b]	9.25[b]	0.59
Red blood cell	5.78	5.70	5.95	0.14
White blood cell (10^6/dL)	4.05	5.30	4.10	0.30
MCV (fl)	64.05[a]	45.70[b]	46.30[b]	3.11
MCH (pg)	21.33[a]	16.90[b]	15.45[b]	0.95
MCHC (g dL^{-1})	33.33	33.33	33.30	0.02
Lymphocyte (%)	66.25	68.50	67.25	1.07
Neutrophil (%)	26.50	26.00	27.00	0.65
Eosinophil (%)	2.50	1.50	2.25	0.26
Basophil (%)	0.50	0.25	0.00	0.13
Monocyte (%)	4.50	3.75	3.75	0.30

[a,b]Means with different superscript along the same row are significantly ($p<0.05$) different, Control: No soybean haulms inclusion, SHD: 30% inclusion of soyabean haulms, SHGD: 30% inclusion of soyabean haulms+0.5% inclusion of garlic and SEM: Standard error of mean

Table 4: Serum indices of sheep fed diets containing soybean haulms with/without garlic powder

	Treatment diets			
Parameter	Control	SHD	SHGD	SEM
Total protein (mg dL^{-1})	6.20[a]	5.40[b]	5.23[b]	0.18
Albumin (mg dL^{-1})	2.63	2.45	2.45	0.05
Glucose (mg dL^{-1})	68.70	62.03	58.43	3.16
Total Cholesterol (mg dL^{-1})	93.18	84.13	79.40	4.28
Triglyceride (mg dL^{-1})	176.48	172.80	165.50	3.26
High density lipoprotein (mg dL^{-1})	22.90	22.73	23.03	0.33
Low density lipoprotein (mg dL^{-1})	35.58	26.88	24.63	4.09

[a,b]Means with different superscript along the same row are significantly ($p<0.05$) different, Control: No soybean haulms inclusion, SHD: 30% inclusion of soyabean haulms, SHGD: 30% inclusion of soyabean haulms+0.5% inclusion of garlic and SEM: Standard error of mean

Table 5: Oxidative biomarkers and blood metabolites of sheep fed diest containing soybean haulms with/without garlic powder

	Treatment diets			
Parameter	Control	SHD	SHGD	SEM
Malondehyde (U mg^{-1} protein)	0.15	0.14	0.15	0.004
SOD (U L^{-1})	97.70	86.83	93.28	3.30
Glutathione peroxidase (μ mg^{-1} protein)	62.73	58.33	58.88	1.58
Uric acid (mg mL^{-1})	6.85[a]	5.75[b]	5.68[b]	0.22
K (mmol L^{-1})	5.08	5.65	5.97	0.19
Cholride (mmol L^{-1})	97.48	100.55	103.35	2.63
Ca (mmol L^{-1})	9.60	10.30	9.93	0.36
Na (mmol L^{-1})	100.45	99.70	107.95	1.76

[a,b]Means with different superscript along the same row are significantly ($p<0.05$) different, Control: No soybean haulms inclusion, SHD: 30% inclusion of soyabean haulms, SHGD: 30% inclusion of soyabean haulms+0.5% inclusion of garlic and SEM: Standard error of mean

DISCUSSION

Using crop residue in complete diets for ruminants has become essential for sustainable livestock production. Soybean haulms inclusion in sheep diets did not adversely affect the performance of the animals. The similar growth indicators observed at the inclusion of soybean haulms in a complete diet at 30% compared to the control diet (without soybean haulms) indicate that the haulms could be viable feed resources for feeding ruminants. Adu and Osuhor[17] reported that yearling red Sokoto goats fed complete diets at the 40 and 50 levels of soybean haulm inclusion had better total feed intake, live weight gain and feed efficiency than when soybean haulms were fed solely. Similar to the findings of this report, the feed conversion ratio in sheep remained unchanged when soybean straw replaced hay in the diet of yearling male intact Gumuz sheep[18].

On the contrary, dry matter intake improved with a 20% inclusion of soybean hay in the diets of goats compared to control as against the similar results for feed intake obtained in this report[19]. The level of inclusion of soybean haulms and the species of animals would have accounted for the differences in dry matter intake in these two reports. It should be noted, however, that the addition of garlic powder (rumen modulator) as a feed additive to improve utilization of soybean haulms in sheep did not impact significantly on the growth indicators.

Nutritional studies should ensure the welfare and health of animals if such feed management strategies are sustainable. The trend observed in the reduction in packed cell volume (PCV), hemoglobin (Hb) concentration, mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) is evident in the significant and consistent relationship found between PCV and Hb concentration. Although there was a reduction in PCV and Hb in diets containing soybean haulms, the values obtained were within the normal range of 27-45% and 9-15 g dL^{-1}, respectively, reported Radostits *et al.*[20] for clinically healthy sheep. The reduction in PCV and Hb in this study did not indicate the presence of an active erythropoiesis condition, given that such an effect may not have impacted the animals with similar values of MCHC obtained across all treatment groups. Also, similar lymphocyte and neutrophil counts observed in this study are suggestive that the soybean haulms diets did not contain toxic substances such as pesticide poisoning to warrant a reduction in hemoglobin and packed cell volume. On the contrary, higher PCV hemoglobin was observed in sheep fed a mixed ration of crop residue[21]. The type of crop residue utilized and the mixture could have accounted for the differences in that report and the current study.

This current study suggested that decreased total protein in sheep may indicate the lower digestive efficiency of coarse roughage by sheep. Yami and Merkel[22] reported that sheep have less digestive efficiency for coarse roughage compared to other ruminants. This effect of possible lower digestive efficiency was also not remedied by adding garlic powder to the diet, as similar crude protein concentrations were observed in both SHD and SHGD, respectively.

Even though the concentration of serum uric acid (UA) in each individual may be affected by a number of factors including genetics, body weight and lifestyle, diet and its purine content can also affect its concentration in the blood. Compared to the control, the reduction in uric acid in soybean haulm-based diets may be due to relatively low purine content associated with low-protein content in crop residue. Soybean haulms may contain other favorable components in reducing urate in the animals. This is good for the animal's well-being, given that reduction in uric acid implies improved antioxidant capacity.

The use of varying levels of soybean haulms in the diet of sheep could ascertain the level to which this feed ingredient could be utilized in ruminant feeding. Further research will be required on the use of different levels especially levels above the one used in this current research.

CONCLUSION

Including soybean haulms in the complete diet of sheep at 30% will be a viable alternative feed resources for the animal. Soybean haulms reduced plasma uric acid in sheep, which indicates improved animal antioxidant capacity. The addition of garlic powder in a complete diet containing 30% soybean haulms did not improve the sheep's performance.

SIGNIFICANCE STATEMENT

The utilization of soybean haulms in a complete diet may be a sustainable alternative to a ruminant feeding system. This study has established that dietary 30% inclusion of soybean haulms in complete diets maintained growth performance and physiological status of sheep with possible improvement in the antioxidant status of the animals. The addition of garlic powder at 0.5% did not further improve the utilization of soybean haulms by the sheep. The study has established that soybean haulms could be an alternative feedstuff for sheep feeding systems.

REFERENCES

1. Halmemies-Beauchet-Filleau, A., M. Rinne, M. Lamminen, C. Mapato, T. Ampapon, M. Wanapat and A. Vanhatalo, 2018. Alternative and novel feeds for ruminants: Nutritive value, product quality and environmental aspects. Animal, 12: s295-s309.
2. Kumar, D. and P. Kalita, 2017. Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. Foods, Vol. 6, No. 1. 10.3390/foods6010008.
3. Mamatha, N., K.C. Shaker, G. Padmaja and M.M. Reddy, 2018. Influence of nitrogen and sulphur application on yield and quality of soybean (*Glycine max* L.). Int. J. Curr. Microbiol. Appl. Sci., 7: 3452-3457.
4. Nkoa, R., K. Kendall and B. Deen, 2014. Ecozone dynamics of crop residue biomass, macronutrient removals, replacement costs, and bioenergy potential in corn-soybean-winter wheat cropping systems in Southern Ontario. Can. J. Plant Sci., 94: 981-993.
5. Smil, V., 1999. Crop residues: Agriculture's largest harvest: Crop residues incorporate more than half of the world's agricultural phytomass. BioScience, 49: 299-308.
6. Beigh, Y.A., A.M. Ganai and H.A. Ahmad, 2017. Prospects of complete feed system in ruminant feeding: A review. Vet. World, 10: 424-437.
7. Ikyume, T.T., O.S. Sowande, P.A. Dele, A.O. Yusuf, S. Monday, O.K. Egunjobi and O. Fatoba, 2017. Effect of varying levels of garlic (*Allium sativum*) powder on growth, apparent nutrient digestibility, rumen ecology, blood profile and cost analysis of feeding West African dwarf goats. Malays. J. Anim. Sci., 20: 61-74.
8. Ikyume, T.T., T. Afele, D.S. Donkoh, J.M. Aloko and U. Suleiman, 2020. Comparative effect of garlic (*Allium sativum*) and ginger (*Zingiber officinale*) and their combination on growth, rumen ecology and apparent nutrient digestibility in sheep. Niger. J. Anim. Prod., 47: 227-238.

9. Echi, I.M., E.V. Tikyaa and B.C. Isikwue, 2015. Dynamics of daily rainfall and temperature in Makurdi. Int. J. Sci. Res., 4: 493-499.
10. Stanworth, S.J., K. Denton, J. Monteath and W.N. Patton, 1999. Automated counting of platelets on the Bayer ADVIATTMM 120 analyser. Clin. Lab. Hematol., 21: 113-118.
11. Stephen, A.I., S.T. Ubwa, O.G. Igbum, S.S. Hati and N.I. Alex, 2017. Analytical comparison between microhematocrit and automated methods for packed cell volume (PCV) determination. Int. J. Hematol. Blood Disord., Vol. 2.
12. Nkrumah, B., S.B. Nguah, N. Sarpong, D. Dekker, A. Idriss, J. May and Y. Adu-Sarkodie, 2011. Hemoglobin estimation by the HemoCue® portable hemoglobin photometer in a resource poor setting. BMC Clin. Pathol., Vol. 11. 10.1186/1472-6890-11-5.
13. Abdalla, S.E. and A.M. Abdelatif, 2008. Effects of haemorrhage on thermoregulation, heart rate and blood constituents in goats (*Capra hircus*). Pak. J. Biol. Sci., 11: 1194-1203.
14. Babaeenezhad, E., N. Nouryazdan, M. Nasri, H. Ahmadvand and M.M. Sarabi, 2021. Cinnamic acid ameliorate gentamicin-induced liver dysfunctions and nephrotoxicity in rats through induction of antioxidant activities. Heliyon, Vol. 7. 10.1016/j.heliyon.2021.e07465.
15. Afele, T., T.T. Ikyume, R.P. Allu, O.S. Aniche, M.E. Onuh and E. Agbo, 2020. Effects of garlic (*Allium sativum*) and ginger (*Zingiber officinale*) powder and their combination on antioxidant and hematological response in sheep. Malays. J. Anim. Sci., 23: 29-39.
16. Ikyume, T.T., S.A. Eze, A.F. Lateef, J.A. Anawo, D.S. Donkoh and S. Ojila, 2022. Blood profile and oxidative biomarkers in goats on cassava based diets containing varying levels of sodium humate. Bulg. J. Anim. Husb., 59: 59-66.
17. Adu, I.F. and C.U. Osuhor, 1993. The utilization of complete diets containing soyabean haulms by goats. Niger. J. Anim. Prod., 20: 56-60.
18. Alebel, M.G., M. Urge, G. Assefa, B. Worku and A. Abebe, 2019. The effect of using either soybean or groundnut straw as part of basal diet on body weight gain, and carcass characteristics of Gumuz Sheep. Int. J. Livest. Prod., 10: 70-76.
19. Adamu, H.Y., O.A. Adesina, S.B. Abdu, M.R. Hassan and D.D. Dung *et al*., 2016. Comparative study on intake, digestibility and nitrogen balance of cowpea, groundnut and soybean hays in a mixed diet fed red Sokoto bucks. Niger. J. Anim. Sci., 18: 162-172.
20. Radostits, O.M., C.C. Gay, K.W. Hinchcliff and P.D. Constable, 2007. Veterinary Medicine: A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs, and Goats. 10th Edn., Saunders Ltd., Edinburgh, Scotland, ISBN: 9780702027772, Pages: 2156.
21. Omotosho, S.O., F.T. Ajayi, B.A. Boladuro and P.C. Emerue, 2021. A mixed ration of crop residues: Effects on rumen fermentation characteristics and blood indices of West African dwarf sheep. Niger. J. Anim. Prod., 48: 348-362.
22. Yami, A. and R.C. Merkel, 2008. Sheep and Goat Production Handbook for Ethiopia. ESGPIP, Brana Printing Press, Addis Ababa, Ethiopia, Pages: 341.