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Research Article

Bamboo leaf as quality fodder supplement for goat production in the dry semi-deciduous forest zone of Ghana

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Abstract

Limited access to fodder with fair nutritive characteristics especially during dry periods is a challenge to livestock farming. However, it is envisaged that evergreen bamboo with year-round litter production and high nutritive characteristics, may provide a valuable supplementary source of feed. In Ghana, bamboo use as fodder is largely unknown and efforts to promote its use will require an understanding of base feed quality and results disseminated. Therefore, a field fodder quality experimentation using twenty Djallonké kids (juvenile goats) of 1-year-old with a mean initial weight of 13.77 ± 1.16 kg for the trial and allotted to four dietary treatments in a completely randomized block design with five replicates per treatment was conducted. The study sought to assess the effect of leaves of two bamboo species (*Oxytenanthera abyssinica* and *Bambusa balcooa*) as a feed supplement to goats fed on basal diets of *Pennisetum purpureum* and *Brachiaria decumbens*. The fodder quality results indicated that nutrient composition and *in vitro* gas production of the treatments varied significantly among the grasses and the bamboo supplement. The highest crude protein and *in vitro* gas production was observed in *O. abyssinica*. Besides, *O. abyssinica* diets recorded the highest daily gain and the lowest feed-to-gain ratio. The treatment effect was significant on blood variables measured. Bamboo leaves are a viable feed supplement for goats as shown by their nutrient profile and positive influence on the growth performance of goats. Hence, the leaves of any of the bamboo species could be used as supplemental feed for goats.

Introduction

Livestock production remains a major livelihood strategy for most of Ghana's agrarian communities. An investment in this industry is crucial for alleviating poverty and enhancing food security [1]. The Ministry of Food and Agriculture (MoFA) reports that access to sustainable feed supply is a major challenge to the livestock industry [2] Most livestock is kept on a free-range system in Ghanaian agrarian communities. Thus, forage of good nutritive value for livestock production is normally scarce and there is a remarkable decline of highly palatable and productive perennial grasses in the dry season owing to recurrent droughts, continuous over-grazing, loss of soil fertility, climate variability, and lack of range improvement interventions [2]. Further, most farmers are unable to provide supplementary feed which hinders livestock production in the country [2]. Khan and Habib [3] report that dietary supplements are required in order to attain adequate levels of glucose and glycogenic compounds to support high livestock productivity. Supplementation of crude protein, minerals, and vitality feeds optimizes microbial fermentation and improves animal productivity [4,5].

The consumption and demand for livestock products in recent times have increased [6]. This is a result of growing economies, rising incomes, and changes in lifestyle, urbanization, and the associated shrinking land area [7]. Efforts at mitigating food insecurity in the ever-increasing global population largely depend on optimum utilization of

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non-conventional feed resources to sustain global livestock production [8]. Several studies have therefore explored the potential of non-conventional feed resources as supplements for livestock production [9-11]. For example, Waghorn [9] reported that tree leaves have a considerable amount of crude protein and mineral-rich favorable for high livestock production, especially in the dry periods.

Non-conventional feed resources which include evergreen bamboo are considered among the valuable supplementary sources of feed that produce a year-round litter with relatively high nutritive characteristics [12]. The use of bamboo leaves as supplementary feed has increased the growth rate of cattle and milk production [13]. Leaves of 27 bamboo species were also found to be rich in crude protein and low in fiber [14]. Many countries globally are exploring bamboo resources as an alternative supplement. For instance, in India, bamboo leaves are traditionally exploited as fodder to augment the conventional feed resources in livestock production [13]. In Nepal also, the potential of bamboo leaves as fodder for goats and sheep has been reported [15].

Recently, in Ghana, the International Bamboo and Rattan Organization (INBAR) has been steering a bamboo-based agroforestry model in the dry semi-deciduous forest zone to promote the integration of bamboo into indigenous cropping systems to advance its utilization in the livestock industry. However, studies on the use of bamboo as fodder are largely unknown. Information on the nutrient profile and growth response to bamboo feed intake is virtually non-existence in Ghana. An understanding of the quality and nutritive content of bamboo leaves as fodder is important in promoting its utilization as supplementary feed in livestock production at the local level.

The study sought to provide key data on the nutritional profile of bamboo leaves as a supplementary diet in goat production. Therefore, the objectives were: 1. to compare the nutritional content of *Oxytenanthera abyssinica and Bambusa balcooa*. 2. to determine the effect of bamboo leaves on the intake and growth of goat feed as a basal diet of *Pennisetum purpureum* and *Brachiaria decumbens* and 3. to assess the effect of bamboo leaves supplementation on the blood content of goats. It is hypothesized that bamboo leaves as supplement feed to common grasses such as *Brachiaria sp.* and *Pennisetum sp.* to goats, will enhance their feed intake, improve growth performance and blood profile; and the knowledge of farmers on the use of bamboo leaves as fodder could facilitate the adoption process and strategies of integrating bamboo into farmland ecology in Ghana.

Materials and methods

Study site

The study was carried out at Jeduako in the Sekyere Central District of Ghana; located within Lat. 06°55¹ and 07°30¹N and Long. 05°00¹ W (Figure 1). The district covers a total land area of 1564 km² and has 150 settlements with 70% being rural. The research area falls within the Dry Semi-Deciduous Forest Zone of Ghana. It is characterized by a bimodal rainfall pattern with an average annual rainfall of 1270 mm. The major rainy season starts in March with a major peak in May. There is a slight dip in July and a peak in August, tapering off in November. December to February is a very long season, which is warm and dusty (the driest period). The area has a mean annual temperature of 27 °C, with variations in mean monthly temperature ranging between 22°C and 30°C throughout the year. The soil type of the study site is sandy loam (Ejura – Denteso Association). Subsistence agriculture is the main economic activity engaging about 65% of the population. The majority of agricultural production is from manually cultivated rain-fed crops. The intercropped range of rain-fed crops differs with greater potential for maize, plantain, beans, cassava, and yam. This agroecological zone was chosen because of its unique characteristic features which combine those of the forest and savanna zones. The grassland/ rangeland vegetation in this zone favors livestock production; but this is currently being challenged by excessive anthropogenic activities like overgrazing, harvesting of wood for fuelwood, and agricultural 'extensification'. This has reduced fodder availability for livestock (especially goats-which is predominant in this area) production and therefore the need to explore alternative fodder sources is paramount. It is the zone where the Forestry Commission of Ghana has proposed and earmarked massive community tree (including bamboo) planting for fuelwood production [16]. Therefore, bamboo fodder could probably be a suitable and readily available future fodder source if proven to be of the required quality and acceptable to the community.

Data collection

Location and source of materials for fodder quality trial: *Pennisetum purpureum*, *Brachiaria decumbens,* and the bamboo leaves used for the study were obtained from the International Bamboo and Rattan Organization (INBAR) project site at Jeduako in the Sekyere Central District of Ashanti Region, Ghana, and the surrounding communities. Twenty Djallonké kids (juvenile goats of an average age of 1 year) with a mean initial weight of 13.77 ± 1.16 kg were obtained from the Ejura Goat Breeding Station of MoFA and transported to the Department. They were tagged, dewormed, and put on antibiotics and multivitamin injections. They were allowed to open-graze before confining them in the goat barn for the trial. The choice of goats for this fodder quality trial was because goat production was seen from the focus group discussions and the initial farmer perception study as the most preferred livestock in the study region.

Preparation of the goat barn: Thirty (30) barns measuring 4x7ft were renovated by cementing the floor, and changing the slabs and the wire mesh.

Carting of fodder and sample preparation: The grasses and the bamboo leaves were baled with a box baler and carted respectively from the surrounding communities, and from Jeduako in the Sekyere Central District of Ashanti Region to the Department of Animal Science. Representative samples were obtained from the bale and milled through a 2mm screen for chemical analysis and *in vitro* gas production.

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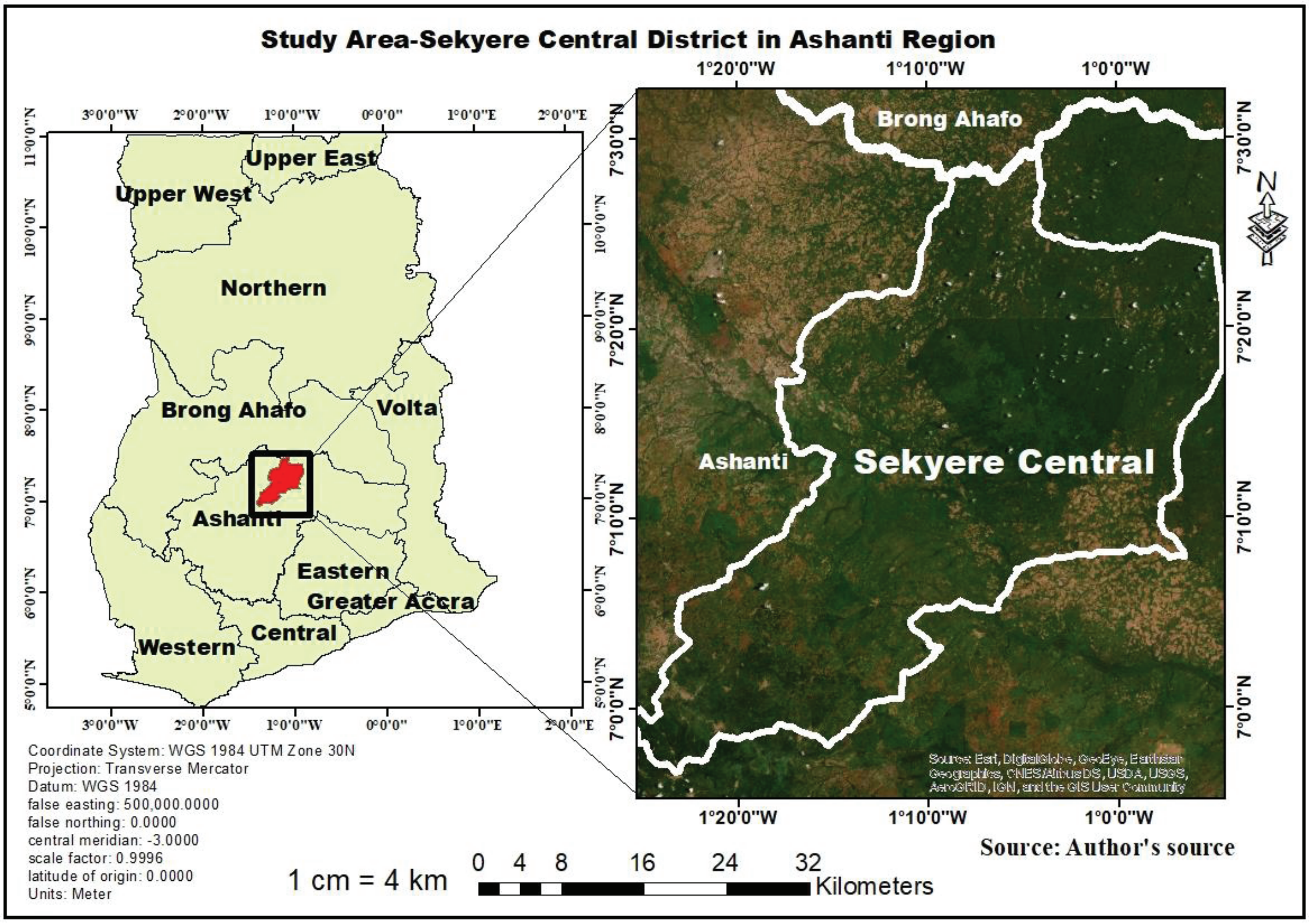

Figure 1: Map of Ghana showing the study area.

Chemical analysis

The chemical analysis adopted the procedures of AOAC [17]. Respectively, 2.0g triplicate samples and the 0.5g triplicate sample were used for the neutral detergent and acid detergent fibers (NDF and ADF), adopting the Ankom Daisy technique.

In vitro gas production assays

Approximately 200 mg triplicate samples of the dry matter (DM) of each sample were placed in a 100 ml graduated glass syringe filled with 10mL of rumen fluid, and 20mL of buffer [18]. Pistons were lubricated with Vaseline and inserted into the syringes. The rumen fluids were sampled from rumens of goats with permanent rumen fistula. Rumen digesta was squeezed through four (4) layers of cheesecloth, homogenized, and kept at 39°C in a water bath under continuous flushing with CO_2 before use. In the hourly interval, the syringes were shaken to record gas volumes at 3, 6, 12, 24, 48, 72, and 96 h of incubation and corrected for blank syringes incubated in each run.

The model below was used for the calculation of gas production (GP):

$GP = b\,(1-Exp\,(^{-ct}))$ (Equation 1)

Where b = potential gas production

c = rate of gas production

GP = gas produced at time t

Goats preparation and experimental design

Twenty Djallonké goats with a mean initial body weight of 13.77 ± 1.16 kg and approximately 1-year of age were used for the trial. The goats were fed a basal diet of *Pennisetum purpureum* and *Brachiaria decumbens* and a supplement of *Oxytenanthera abyssinica* and *Bambusa balcooa*. The diets were chopped into 2.5 cm pieces and offered *ad libitum* in two equal proportions, twice daily (0900h and 1600h). The basal diets were given after the complete consumption of the supplement. Urea molasses block was given *ad libitum* to the experimental animals in the individual cages. Five goats were randomly allocated to four dietary treatments namely; 1) *Pennisetum purpureum* plus *Oxytenanthera abyssinica* 2) *Brachiaria decumbens* plus *Oxytenanthera abyssinica* 3) *Pennisetum purpureum* plus *Bambusa balcooa* 4) *Brachiaria decumbens* plus *Bambusa balcooa* in a completely randomized block design with five replicates per treatment. Before the experiment, the animals were maintained on the experimental diets for a two-week adjustment period. The feeding trial was carried out for 12 consecutive weeks.

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Blood sampling and parameters measured

Blood samples were collected from all the goats in the four treatments prior to and immediately after the trial. Five milliliters (mL) of blood were collected from each of the animals via the jugular vein. Subsequently, three milliliters (mL) were emptied into a vial containing Ethylene Diamine Tetra Acetic Acid (EDTA) for hematological study. Immediately, the bottles were capped and the content was mixed gently for approximately a minute by repeated inversion or rocking. The remaining 2 mL was emptied into another vial free of Ethylene Diamine Tetra Acetic acid (EDTA) for biochemical studies. The blood from both sampling units was analyzed immediately after collection in the Haematological and Biochemical laboratory at KNUST's Hospital. Parameters measured included red blood cells, white blood cells, total protein, and albumen.

Statistical analysis for fodder quality trial

Data from the chemical composition and feeding trial were analyzed as replicated completely randomized and completely randomized block designs respectively using Wang and Goonewardene's [19] approach. The gas production assay adopted the PROC NLINMIXED procedures of SAS. Where there was a significant effect (at $p < 0.05$) treatment means were compared by least-square means. The mean separation was done using Student-Newman-Keels Test.

Results

Gas production

The result of the gas production from the four types of grass is shown in Table 1. The grasses significantly differed ($p = 0.0037$) in the quantity of readily fermentable material (a %) and the potentially fermentable fraction (b %) ($p < 0.0001$) as well as the rate of gas production $k(h^{-1})$ ($p = 0.0007$). The *P. purpureum* (5.1677) *and B. balcooa* (3.5967) had the highest percent readily fermentable material ($P = 0.0037$) while *B. decumbens* (1.0963) and *O. abyssinica* (0.3800) recorded the lowest readily fermentable material. Different pools ($p = 0.0037$) of digestible fiber (represented as "b") that fermented at different rates (P = 0.0007) were observed among the grasses.

The highest gas accumulation was recorded by *O. abyssinica* and the least by *P. purpureum* and differed significantly (p>0.05) among the various feedstuffs (Figure 2).

Chemical composition of grasses used as fodder

The chemical composition of the grasses used in the study is shown in Table 2. The mean dry matter (DM) of the grasses was 276.37 g/kg with the two bamboo species recording a higher DM ($p < 0.0001$) than *B. decumbens and P. purpureum*. Crude protein (CP) is an important indicator of the nutritional quality of feedstuff. The CP of the species under study was highly variable ($p = 0.0009$) ranging from 66 g/kg DM (*P. purpureum)* to 124 g/kg DM (*O. abyssinica)*. The *Oxytenanthera abyssinica* recorded the highest CP ($p < 0.001$) among the grasses assayed and was 1.3, 1.87 times greater than *B. balcooa* and *B. decumbens*; and *P. purpureum* respectively.

Table 1: Least Square (LS) means of Dry matter (DM) fermentation (%) of the four grass species.

Species	a (%)	b (%)	$k(h^{-1})$
Pennisetum purpureum	5.1677[a]	10.8303[d]	0.003667[b]
Brachiaria decumbens	1.0963[b]	15.5237[b]	0.05400[a]
Oxytenanthera abyssinica	0.3800[b]	21.5073[a]	0.06767[a]
Bambusa balcooa	3.5967[a]	12.9473[c]	0.06433[a]
SE	0.8232	0.1916	0.005686
p - value	0.0037	<.0001	0.0007

Means with the common superscripts (a, b, c) within columns are not significantly different according to Student-Newman-Keuls Test; Where a = initially fermentable fraction; b = fermentable DM fraction; k = rate constant for fermentation of b; SE = Standard Error. $p = 0.05$

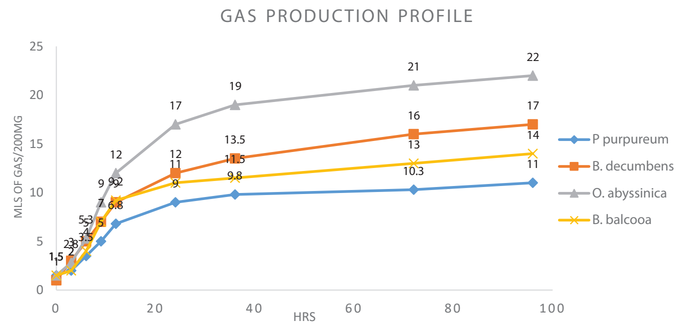

Figure 2: Gas production profiles of grasses and bamboo leaves used in the trial.

Table 2: Nutrient Characteristics of grasses and bamboo leaves.

Feed Type	Chemical composition (g/kg DM)				
	DM	CP	Ash	NDF	ADF
Pennisetum purpureum	206.73[b]	66.07[c]	120.00[a]	502.02[a]	377.97[a]
Brachiaria decumbens	187.30[b]	97.90[b]	115.00[a]	464.16[a]	179.68[b]
Oxytenanthera abyssinica	342.73[a]	124.08[a]	80.00[a]	564.46[a]	367.96[a]
Bambusa balcooa	368.70[a]	95.08[b]	95.00[a]	598.35[a]	326.13[a]
P-value	< 0.0001	0.0009	0.6641	0.1690	0.0097
SE	8.39	4.82	24.83	39.21	29.11

Means with the common superscripts (a, b, c) within columns are not significantly different according to the Student-Newman-Keuls test at a 5% significant level. Where SE = standard error. Data are the means of three replicates of the parameters (DM, CP, NDF, and ADF) assayed. DM: Dry matter; CP: Crude Protein; Ash: Ash content; NDF: Neutral Detergent Fiber and ADF: Acid Detergent Fiber.

Feed intake and weight gain

The crux of feed intake in goats is crucially important linking it to weight gain nexus. Relying on the results of this study (Table 3), the basal feed intake by the goats were statistically comparable among all the treatment (T1 = 88.790g DM/d), (T2 = 89.440 g DM/d), (T = 81.227 g DM/d) and (T3 = 88.913 g DM/d). Also, the paired treatment analysis showed comparatively (65.48g) same weight impact for T2 and T4. However, the highest and lowest weight gained impact was observed in T1 (77.38g) and T3 (38.09g) respectively (Table 3).

Feed conversion ratio

A high feed conversion ratio (FCR) is an indication that animals do not efficiently utilize ingested feed to body mass. The type of feed significantly influenced the FCR ($p = 0.045$) with *Pennisetum purpureum* plus *Oxytenanthera abyssinica* (T1)

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Table 3: Effect of bamboo leaves supplementation on the intake and growth performance of goats

Parameters	Treatment				P-Value	SE
	T1	T2	T3	T4		
Basal feed intake (g DM/d)	88.790ᵃ	89.440ᵃ	81.227ᵃ	88.913ᵃ	0.051	3.779
Supplement Intake (g DM/d)	130.75ᵃ	158.94ᵃ	129.20ᵃ	146.77ᵃ	0.056	18.110
Total Feed Intake	219.54ᵃ	248.38ᵃ	210.42ᵃ	235.68ᵃ	0.061	20.555
Average Daily gain (g)	77.38ᵃ	65.48ᵃᵇ	38.09ᵇ	65.48ᵃᵇ	0.047	7.467

n = 5 for each treatment group. Where T1 = *Pennisetum purpureum plus Oxytenanthera abyssinica*; T2 = *Brachiaria decumbens* plus *Oxytenanthera abyssinica*; T3 = *Pennisetum purpureum* plus *Bambusa balcooa* T4 = *Brachiaria decumbens* plus *Bambusa balcooa*; FCR = Feed conversion ratio (intake /gain). Means with common superscripts (a, b) within rows are not significantly different according to Student-Newman-Keuls Test at a 0.05 significant level.

and *Pennisetum purpureum* plus *Bambusa balcooa* (T2) groups recording the lowest and highest FCR respectively. Goats in the *Pennisetum purpureum* plus *Oxytenanthera abyssinica* group efficiently utilized the feed into building body tissues hence the highest weight gain was obtained by the animals within that treatment group. The highest FCR for animals in the *Pennisetum purpureum* plus *Bambusa balcooa* group explains the lower weight gain of sheep in that group (Table 3).

Haematology and blood biochemistry of goats fed a supplement of bamboo leaves

The blood profile of animals is an important indicator of animal health. Red blood cell (RBC) count in the blood showed significant differences ($p < 0.05$) due to the treatment effect while the white blood cell (WBC) count, total protein, and albumin showed no significant differences ($p > 0.05$) (Figures 3 a-d). The current study recorded RBC (5.8 - 8.0 L^{-1}), total protein (63 - 70 g dL^{-1}), and albumin (23 - 28 g dL^{-1}). Generally, there was a decline in the parameters measured at the end of the trial except for an increase in WBC (Figures 3 a-d) which may have resulted from protein availability in the treatments. The WBC recorded in the current study ranged between 30.0 x 10^9/L and 40.0 x 10^9/L whiles the range of values for total protein was between 63 - 70 g dL^{-1} and that of albumin was between 23 - 28 g dL^{-1} (Figure 3 c, d). The range of values recorded for total protein in the present study was (63 - 70 g dL^{-1}) and that of albumin was (23 - 28 g dL^{-1}) (Figure 3a).

Discussions

Gas production

The result of the highest fermentative gas production observed in *O. abyssinica* could be attributed to the relatively high crude protein among the tested grass species. Since gas production is positively associated with feed fermentation, *O. abyssinica* could be described as having a higher feeding value owing to its high gas production. This was evident in the feeding trial where the animal groups receiving the treatment with *O. abyssinica* supplementation significantly recorded the highest average daily weight gains of 77.38 and 65.48g/d (p = 0.0457). The least gas accumulation recorded by *P. purpureum* may be a result of a relatively low concentration of protein and high acid detergent fiber (cell wall content and lignin) as shown in Figure 2. According to Moore and Jung [20] lignin concentration is reported to be negatively correlated with gas production. Rendering on the author's purview, the lignification of cell wall limits the functions of rumen microbial flora such as fermentation or enzymatic breakdown of forage polysaccharides and this may result in lower passage rate and digestibility of the grass.

Chemical composition of grasses used as fodder

The ash content was similar to the grasses. The Neutral Detergent Fibre (NDF) gives an indication of the fiber constituents of feedstuffs as it measures cellulose, hemicellulose, lignin, silica, and tannins. The mean estimate of the Neutral detergent fiber NDF in the grasses is presented in Table 2. No significant difference in NDF was observed among the grasses. The acid detergent fiber (ADF) represents the least digestible fraction of roughages and gives an indication of how digestible a feedstuff is. The ADF in the grasses differed significantly among the treatments with the two bamboo species and *P. purpureum* recording the highest ADF. All grasses did not significantly differ in their chemical compositions with the exception of crude protein (CP) which is an important indicator of the nutritional quality of feedstuff and acid detergent fiber (ADF); which also represents the least digestible fraction of roughages and gives an indication of digestibility of a feedstuff. The CP of the species under study was highly variable with *O. abyssinica* recording the highest CP ($p < 0.001$) among the grasses assayed. The ADF in the grasses also differed significantly among the treatments with the two bamboo species and *P. purpureum* recording the highest ADF. The findings from the present study support a study by Antwi-Boasiako, et al. [21], who reported that *O. abyssinica* leaves have the highest ash and crude protein contents compared with *Bambusa ventricosa* and two varieties of *Bambusa vulgaris (Bambusa vulgaris var. vitata and Bambusa vulgaris var. varigata)*. The high values of CP and ADF observed in the bamboos and also in the combination with the other grasses give a high propensity for bamboo use as a choice supplementary feedstuff for livestock production in the study region [22].

Feed intake, weight gained, and feed conversion ratio

Intake of the basal diets and the supplements averaged 87.1 and 146.4 g/kg respectively and were similar among the treatments (T1 = *Pennisetum purpureum* plus *Oxytenanthera abyssinica*, T2 = *Brachiaria decumbens* plus *Oxytenanthera abyssinica* and T3 = *Brachiaria decumbens* plus *Bambusa balcooa* T4 = *Brachiaria decumbens* plus *Bambusa balcooa*). Likewise, the total feed intake averaged 141.4g/kg with no significant differences observed among treatments. The numerically higher feed intake by animals in *Brachiaria decumbens* and *Oxytenanthera abyssinica* group might be due to the higher nitrogen concentration in the supplement which might have increased microbial fermentation of the feed and hence, an increased passage rate. This current assertion underpins the findings of Radostits, et al. [23].

The average daily weight gain ranged from 38g for animals in *Pennisetum purpureum* plus *Bambusa balcooa* group

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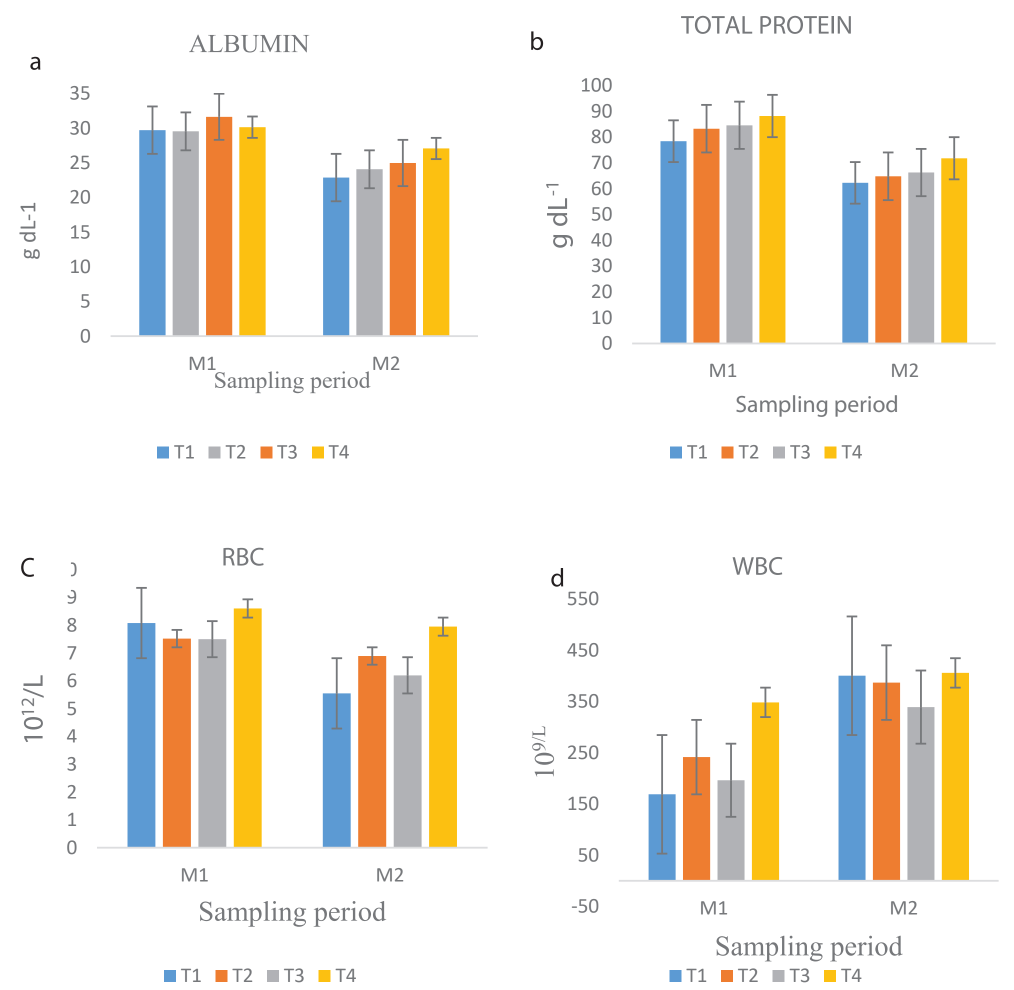

Figure 3: Effect of bamboo leaves supplementation on the Albumin, Total Protein, RBC, and WBC of goats. N = 20.
Where T1 = *Pennisetum purpureum* plus *Oxytenanthera abyssinica; T2 = Brachiaria decumbens* plus *Oxytenanthera abyssinica; T3 = Pennisetum purpureum* plus *Bambusa balcooa T4 = Brachiaria decumbens* plus *Bambusa balcooa;* M1 = Blood measure at the start of the trial, M2 = Blood measure at the end of the trial.

to 77g for animals in *Brachiaria decumbens* plus *Oxytenanthera abyssinica* group. The treatment effect on average daily weight gain was significant. Goats' weights in *Pennisetum purpureum* plus *Oxytenanthera abyssinica*, *Brachiaria decumbens* plus *Oxytenanthera abyssinica*, and *Brachiaria decumbens* plus *Bambusa balcooa* group were significantly higher than those in *Pennisetum purpureum* plus *Bambusa balcooa* group. The relatively lower weight gain recorded in the *Pennisetum purpureum* and *Bambusa balcooa* group may be due to the lower level of feed consumed by the goats in that treatment. The findings from the current study support a study by Galgal, et al. [24], who reported that daily and annual live weight gains from grazing *B. decumbens* comparably exceeded growth rates on *P. maximum* pastures of 0.46 to 0.78 kg/head/day and 0.49 to 0.61 kg/head/day, respectively. The ADG recorded by the goats in this study was however within the range of 44 -109 g/day reported by Muhammad, et al. [25] when rice milling wastes were fed to goats; and greater than 48.98 g/day and 49.19 g/day reported by Obese [26]. Straw with groundnut haulm, cotton seed, and cowpea vines, respectively were fed to the Djallonké goats except for those in *Brachiaria decumbens* and *Oxytenanthera abyssinica* group. Animals in the *Pennisetum purpureum* plus *Oxytenanthera abyssinica* group efficiently utilized the feed into building body tissues hence the highest weight gain was obtained by the animals within that treatment group. The highest FCR for animals in the *Pennisetum purpureum* plus *Bambusa balcooa* group explains the lower weight gain of goats in that group [23].

Haematology and blood biochemistry of goats fed a supplement of bamboo leaves

Although there was a decline in the parameters measured at the end of the trial except for the WBC, the results reported in this current study are consistent with those obtained by Bello and Tasdo [27] who fed sheep with sorghum stover supplemented with graded levels of dried poultry droppings. Accordingly, the RBC (5.8 - 8.0 L^{-1}), total protein (63 - 70 g dL^{-1}), and albumin (23 - 28 g dL^{-1}) recorded in the current study compared well with RBC (6.4 - 9.9 L^{-1}), total protein (63 – 71 g dL^{-1}) except the albumin which was 1.5 times lower than those reported by the authors. Compared to the reference range of values (8.0 - 18.0 L^{-1}) for a normal goat as reported by Radostits, et al. [23], the RBC for the treatments was found to be lower. The low

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RBC values recorded herein could be an indication of anemia-related disease during the trial period. The WBC recorded in the current study ranged between 30.0 x 10^9/L and 40.0 x 10^9/L above the normal physiological values (6.93 x 10^9 /L and12.66 x 10^9 /L) reported by Fadiyimu, et al. [28], for a healthy goat. The spike in the WBC might be an indication of an infection during the trial period. The range of values for total protein (63 - 70 g dL^{-1}) and albumin (23 - 28 g dL^{-1}) recorded also compared well with the normal physiological values between 60-93 g dL^{-1} and 30 – 38 g dL^{-1}reported for sheep and goats by Milne, et al. [29] and Borjesson, et al. [30].

Conclusion and recommendation

The current study has revealed that bamboo is a viable feed supplement for livestock especially, goats, as shown by its nutrient profile and the influence on their growth performance. Though bamboo is a non-conventional feed supplement in ruminant livestock production in the study region, the study shows that it is acceptable to the goats which were evident in their higher intake levels when offered *ad libitum*. Hence using bamboo as a feed supplement can increase feed intake of the basal diets and weight by 40% and 2.31kg respectively. Despite the comparably higher CP, gas production, ash, and the positive influence on goats' growth performance, bamboo should be fed alongside leguminous forages, especially in situations when urea molasses block supplementation is not available in the quest to meet the energy-protein requirement of goats and to improve their health status through the supply of the minerals and protein. This study has revealed and added bamboo as a suitable livestock feed source to current knowledge and information on and for livestock production in Ghana. Leaves of any of the bamboo species could be used as supplemental feed for goats, however, we recommend the choice of the leaves of *O. abyssinica* for goats' production in Ghana. This has contributed to increasing the range of livestock feed for possible increased livestock production with the potential of improving the diets (protein source) of the Ghanaian population. This could, indirectly contribute to improving food security in Ghana. Again, bamboo could now be used as a fodder source in the government of Ghana's flagship policy program of 'Rearing for Food Security and Jobs', currently rolled out in Ghana with a pilot in the study region.

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