ISSN No:-2456-2165

# Bamboo Leaves: Hope for Dry Season Ruminant Livestock Production in Ghana

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**Abstract:- In the humid parts of West Africa, including Ghana, ruminant livestock faces a paucity of feed and poor pasture quality, particularly during the dry season when natural vegetation is low in nutrients. The leaves of three bamboo species were chosen for this study: *Oxytenanthera abyssinica, Bambusa vulgaris*, and *Bambusa balcooa*. The leaves were subjected to chemical analyses using standard protocols to emphasize their nutritional quality.Quality indices such as dry matter intake (DMI), digestible dry matter (DDM), and relative feed value were estimated based on the chemical compositions of the feeds. The results showed variable (p <0.05) nutritional compositions with *B. vulgaris*recording the highest DM (81.77%), CP (18.96%), and EE (12.26%).*O. abyssinica* was highest in CF (23.30%) while *B. balcooa* had the lowest(20.48 %). NFE was highest in *B. balcooa* (27.31%), and lowest in *B. vulgaris*(12.23 %).The leaves had similar ash, NDF, ADF, HEM, and CEL contents (p> 0.05), averaging 15.03%, 37.45 %, 25.82 %, 11.82 %, and 25.77 %, respectively. *B. balcooa* had the highest CARB (47.78 %), while *B. vulgaris* had the lowest (34.17 %). *B. balcooa* had the highest NSC (29.55 %), whereas *B. vulgaris* had the lowest (13.68 %). The estimates of DMI, DMD, and RFV were similar(p > 0.05) among the leaves studied and were all ranked as high-quality feeds. In conclusion, the bamboo leavesexhibited high nutritional characteristics and, if appropriately integrated into animal feeds, could increase ruminant livestock performance.**

***Keywords**:- Bambusa balcooa, Bambusa vulgaris, Oxytenanthera abyssinica, chemical composition, relative feed value.*

## I. INTRODUCTION

Ruminant livestock notably cattle, sheep, and goats serve a good purpose in meeting the protein requirement of the growing population in developing countries. In Ghana, these animals play important roles as part of farming systems and also contribute to the social economy. However, sustainable feeding to increase their contribution levels to food security has become an issue. Ruminant animals face feed shortages and poor pasture quality yearly, particularly during the dry season when natural vegetation is low in nutrients (Aye, 2007). During these dry spells, shrubs and some native grasses provide nutritious source of feed for livestock, particularly small ruminants (Ndlovu, 1992).The high cost of conventional feedstuffs, along with seasonal variations, has required the quest for low-cost, easily accessible feed components to boost livestock productivity.

To minimize scarcity, Ojebiyi et al. (2004) stated that a viable replacement feed ingredient should not be a staple item that is directly consumed by humans. The use of fodder trees and shrubs, according to Sultana et al. (2015), could be a possible technique for boosting the quality and availability of feed for resource-constrained ruminant livestock farmers during the dry season. As a result, in most parts of the world, more attention is given to trees and shrubs for feeding cattle, sheep, and goats, with encouraging results (Ayuk et al., 2007).

Bamboohas evergreen leaves which can be used to help alleviate the challenges associated with dry season feeding. It is a non-tree plant that grows in a variety of shapes and sizes in different places of the world. According to Ohrnberger (1999), the bamboo subfamily Bambusoideae includes both woody and herbaceous bamboos, with a total of 1575 species. Bamboo plants belong to the Bambusoideae subfamily of the Gramineae (Poaceae) family and Order Graminales (Armstrong, 2008). This intriguing plant belongs to the Liliopsida class, the Commenlinidae subclass, the Cyperales order, and the Bambusinae tribe (Lartey, 2016).Despite the lack of a comprehensive inventory of Africa's bamboo resources, the continent's bamboo resources are estimated to cover 2.8 million hectares or roughly 13% of the world's total bamboo cover (Lobovikov et al., 2007).Bamboo comes in 15 genera and 43 species, all of which are native to Africa (Kigomo 1997). According to Bystriakova et al. (2004), Africa has the lowest diversity of woody bamboos in the world. Bamboo is plentiful in several West African countries, with the most common bamboo species being *Bambusa vulgaris*. Since its introduction as an exotic species, *B. vulgaris* has become almost indigenous, flourishing along streams and rivers (Lartey, 2016).

In Ghana, four main species of bamboo have been recorded with several varieties: *Bambusa ventricosa McClure, Oxytenanthera abyssinica (A. Rich.) Munro* and two varieties of*Bambusa vulgaris vulgarisSchrad. ex J. C. Wendl. var. vulgaris Hort.* and *B. vulgaris Schrad. ex J. C. Wendl. var. vittata Rivière*(Antwi-Boasiako et al., 2011).*B. vulgaris*, however, is the most common of these species, accounting for over 95% of total bamboo resources (Antwi-Boasiako et al., 2011), with *B. balcooa* (Beema) being newly introduced by INBAR-Ghana, Fumesua, Kumasi. Two different varieties (*B. vulgarisvar. vulgaris* and *B. vulgaris var. vittata*) are considered native (Antwi-Boasiako

ISSN No:-2456-2165

et al., 2011). The green variety (*B. vulgaris var. vulgaris*) is more widespread than the yellow variety (*B vulgaris var. vittata*), which is also widely grown (Ebanyenle et al., 2005). Bamboo is classed as either Leptomorph (monopodial) or Pachymorph (sympodial). Individual culms are found in Leptomorph species such as Phyllostachys edulis, whereas Pachymorph species grow in clumps. Most bamboo species in Ghana are Sympodial/clumping bamboos, which include *Bambusa vulgaris var. vulgaris* and *Oxythenantheraabyssinica*, which are the most common in natural forest stands (Irvine, 1961). Bamboo can also be categorised depending on the forms of branching, according to INBAR (2010). Monoramose (1 branch), bioramose (2 branches), trioramose (3 branches), and multiramose are the four classifications (more than 3 branches).Bamboo's value has been found and summarized in three basic categories: environmental, economic, and social. According to Gielis (2002), bamboo as a plant can be utilised in ornamental horticulture. It is utilized in ecology for soil stabilization, marginal land uses, hedges and screens, and limited land use.It is employed in natural vegetation stands, plantations, and mixed agroforestry systems in agroforestry. It is utilised for a range of utensils in the local industry. Strand boards, medium density fiberboard, laminated lumber, paper and rayon, and parquet are used in the wood and paper industries, in nutrition-based industries, for human young shoots, livestock fodder, and the chemical industries, for biochemical compounds and pharmaceuticals.The majority of bamboo plant uses, however, are limited to the culms, roots, and extracts from the plant, with little or no use for the leaves.

Although there is no documented evidence of bamboo leaves being used as fodder in various developing countries, Farrelly (1984) asserted that the giant panda eats only bamboo, namely its leaves, culms, and roots.Livestock in China and Jamaica also consume the leaves of woody bamboo trees after harvesting the culms (Farrelly, 1984). This is rarely the case in most tropical nations (Ebanyenle et al., 2005), with no exception of Ghana, due to a lack of nutritional information.

Therefore, this study sought to determine the chemical composition and nutritional quality of the leaves of *Oxytenanthera abyssinica, Bambusa vulgaris,* and *Bambusabalcooa* (Beema) bamboos species for livestock production in Ghana and other developing countries where animal food security is a challenge.

## II. MATERIALS AND METHODS

### *A. Study Area*

The research was conducted in the Livestock Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana from May to August 2021. The study site was located in Ghana's semi-deciduous humid forest zone, which receives 1300 mm of rainfall annually. The average daily temperature is 26°C, with daily temperatures ranging from 20 to 35°C and relative humidity of 67 to 80%.

### *B. Sources and Preparation of Forage Samples*

Fresh leaves of *Oxytenanthera abyssinica* (O.A) and *Bambusa balcooa* (B.B) were supplied by the International Network of Bamboo and Rattan (INBAR) from their bamboo agroforestry site in the Ashanti Region of Ghana. The leaves of *Bambusa vulgaris* (B.V) on the other hand were sampled from bamboo stands located near the study area.

The forage samples were chopped into smaller pieces before being oven-dried to a constant weight at 60°C for 48 hours and coarsely milled (Figure 1) in a laboratory mill (Wiley Mill) for subsequent laboratory analysis.

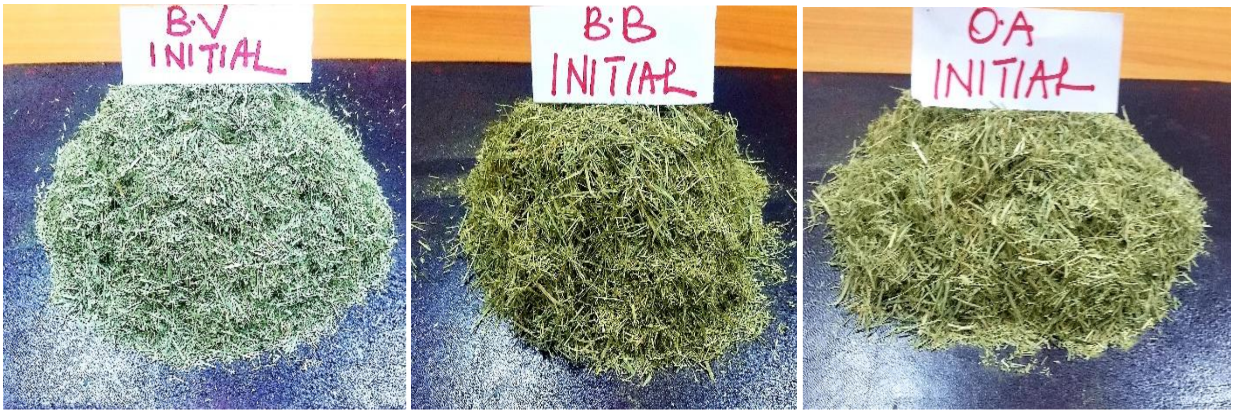

Fig. 1: Oven-dried bamboo leaf millings.Source: Field data, 2021.

### *C. Chemical Analysis of Sampled Forages*

The proximate system was employed following the standard procedures of the Association of Official Analytical Chemists (AOAC, 1990) to determine dry matter (DM), crude protein (CP = N * 6.25), ether extract (EE), crude fibre (CF), and ash. The nitrogen-free extract (NFE) and carbohydrate (CARB) were estimated by the formulae according to Agolisiet al.(2020) as follows:

NFE (%) = 100 - (% moisture + % fat + % crude fibre% + % Protein + % ash) …..(1)

CARB = 100 – (% moisture + % fat + % protein + % ash) … .....(2)

ISSN No:-2456-2165

The ANKOM-200 Fibre Analyser (ANKOM Technology) was used to determine the contents of neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) using the standard procedures of Van Soest *et al*. (1991). The non-structural carbohydrate (NSC) was calculated according to the formula by Van Soest *et al.* (1991) as:

100 – (%NDF + %CP + %EE + %ASH) …....(3)

Hemicellulose (%HEM) and cellulose (%CEL) contents were estimated as proposed by Hindrichsenet al. (2006) as follows:

HEM (%) = %NDF - %ADF …….(4)

CEL (%) = %ADF-%ADL …….(5)

*D. Quality Indices*

Using the estimations of dry matter digestibility (% DDM) and dry matter intake (%DMI), the relative feed value (RFV) index of the leaf biomass as proposed by Grant et al. (1989) was determined. The forages were then compared and ranked using the standard assigned by the Hay Market Task Force of the American Forage and Grassland Council cited in Canbolatet al. (2006). The following formulae were used:

$$\text{DMI, \% of body weight} = \frac{120}{\text{NDF (\% of DM)}} \quad ......(6)$$

$$\text{DDM, \% of DM} = 88.9 - ([\text{ADF (\% of DM)}] * 0.779) \quad .......(7)$$

$$\text{RFV} = \frac{\text{DMI} * \text{DDM}}{1.29} \quad ......(8)$$

*E. Statistical Analysis*

The data were organised in a completely randomized design (CRD) with the forages serving as treatments and the sample locations serving as replicates. The data were further subjected to analysis of variance (ANOVA) using the generalized linear model (GLM) in Minitab Statistical Software. Significant differences among treatment means were tested using Turkey'spairwise comparison at 5% ($p< 0.05$).

## III. RESULTS AND DISCUSSION

*A. Proximate Analysis*

The proximate compositions of the leaf biomass analyzed are shown in Table 1. The proximate compositions varied significantly ($p < 0.05$). The DM ranged from a lower level of 80.43% in *O. abyssinica*, which was comparable ($p > 0.05$) to that of *B. balcooa*, to a high level of 81.77% in *B. vulgaris*, averaging 81.03%. The maximum CP was observed in *B. vulgaris*, which was comparable ($p > 0.05$) to the value observed in *O. abyssinica* (18.96 vs. 16.65%), while *B. balcooa* had the lowest value of 11.98% with an average of 15.85%. Averaging 10.18%, EE ranged from a lower level of 7.31% in *B. balcooa to* 12.26% *in B. vulgaris* whichwas similar ($p > 0.05$) to that *of O. abyssinica.O. abyssinica* was highest in CF (23.30%) followed by *B. vulgaris* (21.94%) while the least value of 20.48% was found in *B. balcooa*with an average of 21.91%.NFE was highest in *B. balcooa*(27.31%), followed by *O. abyssinica* (14.67%) while the least value of 12.23% was recorded for *B. vulgaris*, averaging 8.07%.Ash content was similar ($p > 0.05$) among the bamboo species averaging 15.03%.

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| | Composition (% of DM) | | | | | |
|---|---|---|---|---|---|---|
| **Species** | DM% | ASH% | CP% | EE% | CF% | NFE% |
| ***Bambusa balcooa*** | $80.90^b$ | $13.83^a$ | $11.98^b$ | $7.31^b$ | $20.48^c$ | $27.31^a$ |
| ***Oxytenanthera abyssinica*** | $80.43^b$ | $14.88^a$ | $16.65^a$ | $10.96^a$ | $23.30^a$ | $14.67^b$ |
| ***Bambusa vulgaris*** | $81.77^a$ | $16.37^a$ | $18.96^a$ | $12.26^a$ | $21.94^b$ | $12.23^b$ |
| **Mean** | 81.03 | 15.03 | 15.85 | 10.18 | 21.91 | 18.07 |
| **SEM** | 0.213 | 0.696 | 1.060 | 0.764 | 0.429 | 2.430 |
| **Significant** | 0.004 | 0.374 | <0.001 | <0.001 | 0.001 | <0.001 |

***$^{a, b, c,}$ Means of treatments along a column with different superscripts differed significantly ($p < 0.05$). SEM= standard error of means; DM=dry matter; CP =crude protein; CF = crude fibre; NFE = nitrogen- free extract; EE =ether extract.***

Table 1: Proximate compositions of bamboo leaf samples

*B. Fibre Fractions*

Table 2 summarises the detergent fibre fractions of the bamboo leaves analysed. The NDF, ADF, HEM and CEL contents were similar ($p > 0.05$) in all the bamboo species averaging 37.45%, 25.82%, 11.82% and 25.77% respectively.Averaging 39.97%, the maximum CARB (47.78%) was recorded for *B. balcooa* followed by *O. abyssinica* though similar ($p > 0.05$) to the value obtained for *B. vulgaris* (37.97% vs. 34.17%). The highest NSC (29.55%) was found in *B.balcooa* followed by *O. abyssinica* (20.65%) while the least value of 13.68% was obtained for *B. vulgaris* giving an average of 21.30%.

| | Composition (% of DM) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Species** | NDF% | ADF% | ADL% | CARB% | NSC% | %HEM | %CEL |
| *Bambusa balcooa* | 37.33[a] | 22.26[a] | 0.0051[b] | 47.78[a] | 29.55[a] | 15.08[a] | 22.25[a] |
| *Oxytenanthera abyssinica* | 36.88[a] | 28.61[a] | 0.069[a] | 37.97[b] | 20.65[b] | 8.27[a] | 28.54[a] |
| *Bambusa vulgaris* | 38.72[a] | 26.60[a] | 0.073[a] | 34.17[b] | 13.68[c] | 12.13[a] | 26.52[a] |
| Mean | 37.45 | 25.82 | 0.049 | 39.97 | 21.30 | 11.82 | 25.77 |
| SEM | 0.553 | 1.340 | 0.011 | 2.160 | 2.430 | 1.490 | 1.330 |
| Significant | 0.419 | 0.133 | <0.001 | 0.002 | 0.001 | 0.176 | 0.138 |

*[a, b, c] Means of treatments along a column with different superscripts differed significantly ($p < 0.05$). SEM= standard error of means; NDF =neutral detergent fibre; ADF =acid detergent fibre; ADL=acid detergent lignin; CARB = carbohydrate; NSC =non-structural carbohydrate; HEM =hemicellulose; CEL= cellulose.*

Table 2: Detergent Fibre fraction of selected bamboo leaves

### C. *Relative Bamboo Leaf Quality*

The relative bamboo leaf quality attributes are presented in Table 3. The results showed no difference ($p > 0.05$) in estimates of dry matter intake (DMI), dry matter digestibility (DMD), and relative feed value (RFV) among the bamboo species studied. When compared with the standard, the leaves were all given a primequality grade with their RFV ranging between 163.83 to 178.92.

| **Species** | DMI, % BW | DMD, % | RFV | *RFV Quality |
|---|---|---|---|---|
| *Bambusa balcooa* | 3.23[a] | 71.56[a] | 178.92[a] | Prime |
| *Oxytenanthera abyssinica* | 3.25[a] | 66.61[a] | 168.02[a] | prime |
| *Bambusa vulgaris* | 3.10[a] | 68.18[a] | 163.83[a] | prime |
| Mean | 3.19 | 68.78 | 170.26 | |
| SEM | 0.049 | 1.040 | 3.580 | |
| Significant | 0.441 | 0.133 | 0.223 | |

*Within column, parameters with similar superscripts* are not *significantly different ($p > 0.05$). SEM = standard error of means;DMI = dry matter intake; DMD = digestible dry matter; RFV = relative feed value; *Quality Grading Standard assigned by The Hay Marketing Task Force of the American Forage and Grassland Council, the RFV were assessed as roughages based on prime >151; 1 (premium) = 151-125; 2 (good) = 124-103; 3 (fair) = 102-87; 4 (poor) = 86-75; 5(reject) < 75*

Table 3: Relative bamboo leaf quality indices

## IV. DISCUSSION

The nutritional value of forages is determined by their intrinsic chemical composition, which is influenced by genetics and the surrounding environment. In the present study, the chemical composition of the leaves of the bamboo species studied differs from that reported by Bhandari et al. (2015) for several bamboo species in India and Antwi-Boasiako et al. (2011) for similar bamboo species in Ghana.Genetic variety across bamboo species, as well as geographic factors such as soil type, rainfall distribution, seasonal change, etc., could explain the differences. However, all of the forages had high DM contents, which were similar to residual dry matter seen in various browsing plants studied by Onwuka (2007). Fodder species with more than 300.0 g/kgDM of DM are generally regarded as good fodder (Bhandari et al., 2015). The crude protein level of bamboo species in the current study was higher than that of regularly grazed grasses, which had crude protein concentrations of less than 10% during wet seasons and as low as 4% during dry seasons. However, the values were comparable to the range between 12-30% for tropical leguminous trees reported by Norton (1994), tropical browse by Le Houerou (1980), and the leaves and stems of *Stylosantheshemata* by Attoh-Kotoku (2003). Again, the CP concentration was higher than the 70.0 g/kgDM CP content of pasture grasses required for ruminant voluntary intake and body growth (Nori et al., 2009; Njidda, 2010; Gadberry, 2018). This minimum level is required to avoid a reduction in fodder consumption due to nitrogen deficiency induced by low protein levels (Andriarimalalaet al., 2019).

Bhandari et al. (2015) found that the crude protein content of bamboo leaves ranged from 84.0g/kgDM to 171.0g/kgDM on average, which is consistent with the current study's findings. Furthermore, the bamboo leaves analysed in the present had a higher nutritional value than crop residues like rice straw (50g/kgDM CP and 350g/kgDM CF on the average), which is almost always fed to ruminants during the dry season (Babayemiet al., 2020). However, they were lower in CP content on average than that of *Loliummultiflorum* (200g/kgDM) and *Avena sativa* (150g/kgDM), which are extensively planted and used by livestock farmers during the dry season (FIFAMANOR, 2009). Bamboo leaves are therefore, nutritious feed alternative for animals that require a lot of protein, such as nursing cows and recovering livestock. Because of their high crude protein content, these bamboo leaves are a good source of nitrogen supplement for ruminants fed low-quality fodder, especially during the dry seasons. The total ash content of bamboo leaves is an excellent indicator of the plant's richness in terms of mineral content. However,the ash contents of all bamboo species were higher than 10%, which is considered undesirable (Bhandari et al., 2015). Bamboo species have lower CF values due to their decreased lignin content, indicating possible improved digestion. Indeed, lignin can be linked with polysaccharides and proteins, making enzymatic degradation by rumen microorganisms problematic (Kononott, 2005; Li et al., 2014; Bhandari et al., 2015; Bhardwaj et al., 2019). All of the bamboo species studied in this study exhibited crude fibre content somewhat lower than the 30% reported by Anele et al. (2008) for pasture grass forages. Differences in geographical location and plant maturity could explain the discrepancies, as crude fibre content is affected by plant age and maturity as well as edaphic factors. The total carbohydrateand non-structural carbohydrate values for the bamboo leaves were higher than those in *Amaranthusviridus (*4.7%), *Chenopodiummurale (*3.4%), *Nastritiumofficinale* (3.3%), and *Scandexpectenveneris (*7.3%) reported by Imran et al. (2007). It is worth noting that the leaves had similar NDF, ADF, HEM, and CEL, which could indicate that ruminant voluntary intake and digestibility of these feeds will be similar. This is supported the similar DMI, and DMD estimates observed in the feeds.

## V. CONCLUSION

Comparatively, the chemical constituents and leaf quality indices of bamboo were not affected by species and/or the location where these bamboos were sampled except for dry matter, crude protein, and ether extract contents which differed according to the sequence; *Bambusa vulgaris*>*Oxytenanthera abyssinica*>*Bambusa balcooa.* However, in general, thebamboo leaves hadhigh nutritive value with average voluntary DM intake estimated at 3.19% of animal body weight and average DM digestibility estimated at 68.79%.The high DM content indicates low moisture content and excellent nutritional stability, resulting in minimal microbial propensity and a long lifespan during storage and the high protein content indicates a strong N source and possible amino acid, whereas their high fibre content, combined with high total and non-structural carbohydrate contents, indicates a rich roughage supply. It is suggested that using bamboo leaves in the composition of rations could boost ruminant productivity in Ghana and other developing nations, particularly during the dry season when feed is scarce. However, to corroborate these findings, more *in vivo* dietary experiments are needed.

- **ACKNOWLEDGMENTS:** The researchers are grateful to INBAR for supplying bamboo leaf biomass for this study.

- **CONFLICT OF INTERESTS:** The authors wish to explicitly declare no conflict of interest in this research.

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