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EFFECT OF PROCESSING METHODS ON CHEMICAL AND NUTRIENT COMPOSITION OF BAMBOO (*Bambusae arundinacea*) LEAVES

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ABSTRACT

Due to their abundant macro and micronutrients, some leaves hold a lot of promise as potential forage plants for livestock. However, a major limitation is the high content of anti-nutritional factors that combine with nutrients and reduce their bioavailability. This study, therefore, aimed to evaluate the effect of processing on the chemical and nutrient composition of bamboo leaves. The leaves were subjected to four different physical processing methods; T_1 (control, air drying), T_2 (fermenting in an airtight bag for five days), T_3 (soaking in ordinary water for 24 h), and T_4 (soaking in warm water at 50 ºC for 20 min). Fresh samples of the leaf were also analyzed on a wet basis (T_5). Samples from respective treatment groups were analyzed for proximate composition, mineral constituents, anti-nutritional factors, vitamin C, flavonoids and antioxidant activities following standard procedures. The values obtained were subjected to a one-way analysis of variance using the generalized linear model of SAS. Although there was no significant effect of processing on ether extract and crude fiber, the crude protein content was significantly higher ($P \leq 0.05$) for T_3 and T_4. The ash content was lowest ($P \leq 0.05$) in T_3 compared to other treatment groups. The fiber fractions (acid detergent lignin, neutral detergent fiber, hemicellulose and cellulose) were highest ($P \leq 0.05$) in T_1 than other treatment groups. T_1 had the lowest ($P \leq 0.05$) for phosphorous and potassium. However, T_2, T_3 and T_4 had similar ($P > 0.05$) phosphorous and sodium compositions. The processing effect was not significant ($P > 0.05$) on vitamin C, alkaloids, saponins, and tannin. However, the phytate was highest ($P \leq 0.05$) in T_1. The physical processing of bamboo leaves lowers the antinutrient appreciably without adversely affecting the proximate composition. Further, the high nutrient composition of bamboo leaves, irrespective of processing methods, attests to its potential as an important forage plant.

Keywords: Antinutrients, bamboo leaves, fiber fractions, processing, proximate

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INTRODUCTION

The availability of feed sources and utilization for the ever-expanding livestock represents possibly the most compelling task facing farmers and animal scientists. Studies exploring other sources of feed that are non-conventional, cost-effective, and sustainable with no deleterious effect have been canvassed (Onunkwo and George, 2015; Akinmoladun *et al.,* 2018a). This is on the heel of the high cost of conventional feed sources, which have soared in recent times and becoming uneconomical to use in animal feeds. Bamboo, a woody grass belonging to the family Andropogoneae and subfamily Bambusoideae, has over 1200 species and are naturally distributed over a wide environmental range and continents (Hogarth and Belcher, 2013). Africa has about 43 species of bamboo, out of which five (*Oxynanthera abyssinica, Bambusa vulagaris*, *Dendrocalamus giganteus, Bambusa arundinacea* and *Bambusa tulda)* are domiciled in Nigeria (RMRDC, 2006). Bamboo leaves and other plant parts (shoots, culm sheath and culms) are used for medicine with notable health benefits. This curative effect is attributed to abundant bioactive compounds with a high antioxidant capacity (Thapa *et al.,* 2018). The leaves of *Bambusa arundinaceae* are reported to have anti-ulcer and anti-inflammatory properties and hold a lot of promise as potential forage (Rathmod *et al.,* 2011). Antiwi-Boasiako *et al.* (2011) reported that the crude protein and fiber content from four different bamboo species (*B. ventricosa, B. vulgaris vittata*, *Oxytenanthera abyssinica* and *B. vulgaris vulgaris*) ranged from 18.39 to 19.39% and 25.88 to 33.19%, respectively. This crude protein (CP) content compares well, if not higher, with other commonly used forage such as *Pennisetum purpureum* (11.95%), *Panicum maximum* (5.5%) and *Leucaena leucocephala* (12.80%) (Odouzo and Adegbola, 1992).

The broad distribution of biologically active constituents in plants with potentials as animal feeding stuff has been a concern. The knowledge about these compounds' ability to precipitate both favourable and toxic responses has led to several studies on possible implications in various biological systems (Igile, 2013;

Akinmoladun *et al.,* 2018b). Though they are widely noted as important pharmacologically active agents, most of these secondary metabolites (also known as anti-nutritional factors) elicit harmful biological responses and have a notable effect on animals' health if consumed above a tolerable limit (Mlambo *et al.,* 2015). The concerns about the noxious factors in plants are not only in the toxic effect elicited directly on animals but also the loss incurred monetarily in the cause of preventing or reducing such occurrences. Pharmacological studies of ethanolic/methanolic extract of *B. arundinacea* attributed the anti-diabetic, aphrodisiacs, anti-bacterial, anti-inflammatory, anti-helminthic and anti-arthritic activities to the presence of bioactive chemical compounds (antinutrients) in the plant (Ajay, 2013).

Physical treatment methods (heating, fermenting, soaking in water etc.) have been used extensively to lower antinutrients in plants. The percentage of cyanide in the leaf of *Moringa oleifera* was reduced by 88.10%, 80.95% and 61.90% following boiling, simmering, and blanching, respectively (Sallau *et al.,* 2012). Similarly, the oxalate content in *Arachis hypogaea* L (groundnut) was reduced from 3.04 mg/g to 2.62 mg/g and its trypsin inhibitor from 0.12 TUI/g to 0.09 TUI/g after boiling (Mada *et al.,* 2012). When Asparagus beans (*Vigna Sesquipedis)* were soaked in water, the alkaloids reduced from 0.34 to 0.28%, phytate from 0.18 to 0.09, tannin from 0.23 to 0.09%, trypsin inhibitor from 13.82 to 9.41 TUI/100g; HCN from 8.63 to 5.68% and saponin from 0.42 to 0.24% (Nwosu, 2010). Sarangthem and Singh (2013) subjected fresh bamboo shoots of *Dendrocalamus hamiltonii* and *Bambusa balcooa* to traditional and laboratory fermentation and reported that the phytate content of 35.95mg/100g and 30.67mg/100g was reduced to 22.46mg/100g and 24.12 mg/100g in the samples respectively. It was, however, hypothesized that subjecting bamboo leaves to physical processing will lower their chemical and nutrient composition. Therefore, this study's objective was to assess the effect of processing on bamboo leaves' chemical and nutritional composition.

MATERIALS AND METHODS

Harvesting of leaves and identification: Bamboo leaves were freshly harvested from bamboo culms in plantation sites during the peak of the rainy season and identified at the Department of Forestry, Federal University of Technology, Akure.

Processing techniques: The harvested leaves were washed. About 500 g of the leaves were subjected to the following processing techniques as described in the review of Samtiya *et al*. (2020); ordinary air drying for 2-3 days (control, T_1); fermenting in an airtight silo/container for 5days + air drying for 2-3 days (T_2); soaking in ordinary water for 24 hrs + air drying for 2-3 days (T_3); soaking in water bathe (50^{o}C for 20 minutes) + air drying for 2-3 days (T_4); fresh leaves (analyzed as fresh sample) (T_5). When air drying, the leaves were turned regularly to avert fungal growth. The processed leaf samples were packed into sealed nylon bags, labelled accordingly, and kept frozen (-4 ^{o}C) pending analysis.

Proximate analysis of the samples: Dry matter, crude protein, ether extract, crude fiber and ash contents of the samples were determined using the methods described in AOAC (2005). Nitrogen free extract (NFE) was obtained by subtracting the sum of the percentage of protein, ash, ether extract and crude fiber from dry matter. The Gross energy of the dried material was determined against thermocouple grade benzoic acid using a Gallenkamp ballistic bomb calorimeter.

Mineral Analysis: The mineral content was determined by dry-ashing the samples at 550^{o}C in a furnace, dissolving the ash in 10% HCI, and filtered. Sodium and potassium were determined by a flame photometer, while an atomic absorption spectrometer (AAS) was used to assess calcium and magnesium (AOAC, 2005)

Fiber Fractions: The acid detergent fiber, neutral detergent fiber and acid detergent lignin were determined according to methods described by Van Soest (1991). Hemicellulose was calculated by subtracting acid detergent fiber from neutral detergent fiber, while cellulose was calculated by subtracting acid detergent lignin from the acid detergent fiber.

Determination of antinutrients: Tannin content was determined using the method described by Makkar (2003). Phytin was extracted and precipitated according to the method of Wheeler and Ferrel (1971). Alkaloid was determined using the method described by Harbone (1973) method, while saponin was assayed by the test described by Obadoni and Ochuko (2001). Vitamin C was determined titremetrically by the method of Barakat *et al.* (1973). The free radical scavenging capacity of *B. arundinanceae* leaves against 1, 1-diphenyl-2-picrylhydrazyl (DPPH) was determined by the modified method of Szabo *et al.* (2007). The total flavonoid content was determined according to the method of Ayoola *et al.* (2008).

Statistical analysis: Data collected were analyzed using the generalized linear model (GLM) of SAS (2010). The means were separated using Turkey's Least Significant Difference of the same statistical software where a significant difference exists.

RESULTS

The proximate analysis and fiber fractions of the bamboo leaves subjected to different processing methods are shown in Table 1. The processed leaves (T_1-T_4) were not significantly different (P>0.05) in their dry matter. The crude protein was higher (P≤0.05) in T_3 and T_4 compared to other groups. Processing effects were not significant (P>0.05) on the leaf's ether extract. The percentage of crude fiber was highest (P≤0.05) in T_5 (fresh leaves) compared to the processed leaves' groups that had similar (P>0.05) values. The ash content of the leaves was not affected (P>0.05) by physical processing methods. The neutral detergent fiber was most increased (P≤0.05) in T_1 and lowest in T_5. The effect of physical processing was not significant (P>0.05) on the acid detergent fiber, hemicellulose, and cellulose. Compared to other treated groups, the values recorded for acid detergent lignin for T4 were the lowest (P≤0.05). The gross energy of the processed leaves was not significantly affected (P>0.05) by processing methods.

Table 1. Proximate composition and fiber fractions of bamboo (*Bambusa arundinacea*) leaves subjected to different physical processing methods.

Treatments (%)	T_1	T_2	T_3	T_4	T_5
DM	89.31±0.034^{a}	89.31±0.06^{a}	89.29±0.15^{a}	89.81±0.35^{a}	61.52±0.09^{b}
CP	20.99±0.08^{b}	16.63±0.04^{c}	24.67±0.99^{a}	24.24±1.44^{a}	12.27±0.04^{d}
EE	7.51±0.03^{a}	7.43±0.02^{a}	7.05±0.52^{a}	6.95±0.90^{a}	4.62±0.01^{b}
CF	25.10±1.54^{b}	24.86±0.15^{b}	23.61±0.41^{c}	25.77±0.66^{b}	33.21±0.01^{a}
ASH	11.16±0.11^{a}	11.81±0.39^{a}	9.98±0.27^{a}	10.35±0.17^{a}	6.90±0.01^{b}
NFE	24.54±1.45^{b}	28.59±0.43^{a}	23.94±0.54^{b}	22.50±3.17^{b}	4.53±0.06^{c}
NDF	74.49±0.40^{a}	69.13±0.33^{c}	71.77±0.73^{b}	72.74±0.28^{b}	40.59±0.01^{d}
ADF	49.10±4.69^{a}	43.10±3.07^{a}	51.68±4.09^{a}	46.65±6.53^{a}	26.83±0.27^{b}
ADL	9.33±1.94^{a}	9.29±1.05^{a}	7.92±0.59^{ab}	4.38±1.38^{c}	6.08±0.03^{bc}
HEM	25.39±4.49^{a}	26.03±2.74^{a}	20.08±4.82^{ab}	26.09±6.25^{a}	14.65±0.99^{b}
CELL	39.77±6.63^{a}	33.81±4.11^{b}	43.76±3.49^{a}	42.28±5.15^{a}	21.42±1.18^{c}
G.E (MJ/kg)	333.25±9.05	342.68±9.42	405.23±9.23	385.28±9.68	-----

^{abc}: means with different superscripts along the row are significantly different (P<0.05) from each other. DM=Dry matter; CP= Crude protein; EE= Ether extract; CF= Crude fiber; NFE= Nitrogen free extract; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin; HEM=Hemicelluloses CELL=Cellulose; T_1= Air-dried; T_2= Fermented in air-tight container (5days); T_3= Soaked in ordinary water (24hrs); T_4= Soaked in warm water at 50^{0}c for 20mins; T_5= Fresh bamboo leaves; G.E.=Gross Energy

Table 2. Mineral compositions of bamboo (*Bambusa arundinacea*) leaves subjected to different physical treatments method.

Treatments (%)	T_1	T_2	T_3	T_4	T_5
P	0.03±0.003^{b}	0.04±0.003^{a}	0.04±0.001^{a}	0.05±0.002^{a}	0.02±0.001^{b}
Na	0.21±0.030^{b}	0.24±0.010^{ab}	0.27±0.080^{ab}	0.32±0.090^{a}	0.13±0.010^{c}
K	0.80±0.009^{d}	0.85±0.004^{c}	1.05±0.009^{a}	1.10±0.002^{a}	0.59±0.002^{e}
Ca	1.09±0.160	1.11±0.090	1.27±0.110	1.18±0.110	1.29±0.040
Mg	0.48±0.090^{b}	0.50±0.002^{b}	0.27±0.030^{b}	0.83±0.110^{a}	0.31±0.010^{b}

^{abc}: Means with different superscripts along the row are significantly different (P<0.05) from each other.T_1= Air-dried T_2= Fermented in an airtight container (5days), T_3= Soaked in ordinary water (24hrs), T_4= Soaked in warm water at 50^{0}c for 20mins, T_5= Fresh bamboo leaves, P= Phosphorus, Na= Sodium, K= Potassium, Ca= Calcium, Mg= Magnesium.

Table 3. Phytochemicals and total flavonoid of bamboo (*Bambusa arundinaceae*) leaves subjected to different processing methods.

Parameters	T_1	T_2	T_3	T_4	T_5
Alkaloids (%)	0.84±0.23	0.25±0.21	0.44±0.42	0.40±0.34	0.67±0.04
Saponins (%)	3.98±1.63	3.45±0.29	3.49±0.71	3.34±0.49	2.33±0.04
Tannin (mg/100g)	0.14±0.01	0.11±0.04	0.13±0.00	0.13±0.01	0.11±0.01
Phytate (mg/100g)	42.03±2.33^{a}	32.96±1.17^{b}	38.31±0.59^{ab}	35.85±5.24^{ab}	21.34±0.12^{c}
Flavonoid (%)	2.85±0.14^{bc}	1.85±0.49^{c}	2.30±0.35^{b}	2.55±0.21^{bc}	4.4±0.14^{a}
DPPH (%)	7.01±0.21^{ab}	6.44±0.87^{b}	7.50±0.04^{ab}	7.29±0.33 ^{ab}	7.92±0.11^{a}
Vit.C(mg/100g)	6.29±0.07^{b}	6.87±0.31^{b}	5.35±0.31^{b}	5.87±0.95^{b}	24.60±0.74^{a}

$^{abc:}$ Means with different superscripts along the row are significantly different (P<0.05) from each other.T_1= Air-dried T_2= fermented in an airtight container (5days), T_3= soaked in ordinary water (24hrs), T_4= soaked in warm water at 50^{0}C for 20mins, T_5= fresh bamboo leaves; DPPH=2,2-Diphenyl-1-picrylhydrazyl.

The effect of treatment methods on the macro-minerals of bamboo leaves is shown in Table 2. There were significant differences (P≤0.05) in the phosphorus, sodium and magnesium of the treated leaves and values obtained were highest in T_4. Treatments T_2, T_3 and T_4 were not significantly different (P>0.05) from each other in their Na contents. The potassium was highest (P≤0.05) in T_4 and lowest in T_3. The calcium of the leaves was not influenced (P>0.05) by the different processing methods. The effect of processing was not significant (P>0.05) on vitamin C.

The phytochemical constituents, total flavonoid composition and antioxidant activities of bamboo leaves subjected to different processing methods are shown in Table 3. Processing effects were not significant (P>0.05) on the leaves' alkaloids, saponins and tannins. There was a significant difference (P≤0.05) in the processed leaves' phytate, and the values obtained were highest in T_1. A much increased (P≤0.05) flavonoids and DPPH due to processing effect were recorded in T_5.

DISCUSSION

The proximate analysis results provide a quick estimation of the nutrient potentials of feedstuffs and supply clues for further research, leading to the use of such plants for *in vivo* and in vitro studies. However, the proximate analysis of the feed may not truly reflect the nutritional value. Generally, they help screen the potentials of an assemblage of browse plants beneficial to ruminants as feed.

The dry matter (DM) values of the processed leaves far exceed those reported in western Nigeria by Isah *et al.* (2012) in browse plants fed to ruminants. The range of crude protein (CP) values (16.63-24.67%) of the processed leaves was high and seemed not to be affected by processing effects. Studies have shown that ruminants' browsing behaviour is influenced by the crude protein content of browse plants (Nyamukanza and Sebata, 2020). Although crude protein may enhance palatability, both are not similar since plants contain inherent phytochemicals like tannins that can affect palatability and browse plants' intake (Mlambo *et al.,* 2015). The range of values recorded compares well with the leaves from the multipurpose tree that contains 20% CP or above, and higher than what was reported for grasses and vegetable shrubs. It exceeds the minimum requirements (10-12%) for ruminants (Ayssiwede *et al.,* 2010). The ash content of the processed leaves (9.98-11.81%) was still high despite the treatment effect. This means that the plants contain many inorganic elements (Enri *et al.,* 2020). The mineral elements in the processed leaves were higher than the values reported for *Moringa* (7.96%), *Leucaena* (8.93%) and *Gliricidia* (6.67%) leaf meal (Aye and Adegun, 2013).

The macro-mineral (Ca, P, K, Mg and Na) concentrations were lower in the processed leaves than what was reported by Asaolu *et al.* (2011) for some leaf meal. The mean ether extract content (7.23 %) of the processed leaves was low when compared to *Moringa* (16.41%), *Leucaena* (12.40%) and *Gliricidia* (12.29%) (Aye and Adegun, 2013) but comparable to rice bran (7.5%) and palm kernel cake (8.32%) (Aduku, 1999). The range of acid detergent fiber (43.10-51.68%) and neutral detergent fiber (69.13-74.49%) fractions of the processed leaves in the present study compares favourably to the acid detergent fiber (32.40-55.40%) and neutral detergent fiber (43.5-75.0%) for heavily browsed plants by cattle in southeastern Nigeria (Ahamefule *et al.,* 2006). Compared with low-quality roughages, the neutral detergent fiber and acid detergent fiber range reported were modest and can be easily degraded by ruminants (Nyamukanza and Sebata, 2020). The content of hemicellulose fraction (20.0-26.09%) of the processed plant was high and similar to cassava root chaff (21.6g/100g), but lower than wheat offal (30.3g/100g) (Aderemi *et al.,*1999).

In this study, the tannin levels were below the range (60 to 100g/kg) to depress growth and feed intake. About 2-3% of tannin in ruminants' diets is beneficial due to its role in reducing rumen protein degradation by the protein-tannin complex formed (Mlambo *et al.,* 2015). Plant tannins are complex phenolic polymers and can defer in terms of chemical structure and biological activity. They impede nutrients and enzyme utilization through astringency and reduce forage digestibility. About 5% tannin concentration is the minimum allowed in browses, above which may result in rejection by goats and other herbivores (Cooper and Owen-Smith, 1985). According to a report, dietary tannin levels of 2 and 5% in sheep and cattle, respectively, adversely affect digestibility (Naumann *et al*., 2017). As observed in this study, the range of phytic acid (32.96 to 42.03mg/g) in this study was higher than what was detailed by Onwuka (1996). According to Cowieson *et al.* (2016), the phytic acid-complexes formed usually reduce the bioavailability of protein and minerals when a diet with a phytate content of about 1-6% is fed to monogastric. This is because the phytase enzyme that helps to break down phytin is lacking in monogastric. The high range of phytate observed in this study suggests that the processing methods adopted could not substantially reduce the phytate levels and are likely to affect ruminants adversely. The values reported for saponins and alkaloids in this study were significantly reduced by the processing methods adopted compared to other unprocessed leguminous plants (Aye and Adegun, 2013; Igile *et al.,* 2013). Saponin at the low level (< 10%) is harmless, while higher concentrations can result in dysentery, diarrhoea and gastroenteritis (Agbaire, 2012). The range of alkaloids in this study (0.25-0.84%) was lower than the alkaloid content of 1.2-0.13% reported by

Igile *et al.* (2013) in the leaf of *Vernonia calvaona*. Alkaloids are essential bioactive substances with therapeutic properties as their pure isolates, and synthetic analogues have analgesic, antispasmodic and bactericidal properties.

The range of values reported for flavonoids (1.85-2.85mg/100g) in the present study for the processed leaves was lower compared to what was said for *Moringa* (2.34%), *Leucaena* (4.57%) and *Gliricidia* (5.25%) (Aye and Adegun, 2013). Flavonoids are essential bioactive antioxidant compounds due to their role in preventing oxidative damage as well as their anti-ulcer and anticancer activities (Ullah *et al.,* 2020). The low flavonoid values in the processed leaves could be attributed to processing effects.

Conclusion: The study found that treatment of *B. arundinanceae* leaves by physical methods lower the antinutrients appreciably without adversely affecting the proximate composition.

Conflict of Interest: The author declares no potential conflict of interest

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REFERENCES

Aderemi, F.A., O.O. Tewe, and F.I. Ogundola (1999). Enzymic supplementation of cassava root chaff (CRC) and its utilization by pullet chicks. Trop. Anim. Prod. Invest. 2: 195 – 203

Aduku, A.O. (1999). Tropical feed stuff analysis table. Dept. of Animal Science, Ahmadu Bello, University, Samaru, Zaria, Nigeria

Agbaire, P.O. (2012). Levels of anti-nutritional factors in some common leafy edible vegetables of Southern Nigeria. Afr. J. Food Sci. Tech. 3(4): 99–101

Ahamefule, F.O., B.E. Obua, J.A. Ibeawuchi, and N.R. Udosen (2006). The Nutritive Value of Some Plants Browsed by Cattle in Umudike, Southeastern Nigeria. Pakistan J. Nutr. 5 (5): 404-409

Ajay, K.R. (2013). Bambusa arundinacea (vanshlochan): An Overview. Int. J. Res. Pharmacol. Pharmacotherap. 2(1): 240-255.

Akinmoladun, O.F., V. Adejoro and A. Jimoh (2018a). Performance and carcass characteristics of rabbits fed diets with total or partial replacement of *Tridax procumbens* by bamboo (*Bambusa arundinancea*) leaves. J. Exp. Agric. Int. 27(1), 1-10.

Akinmoladun, O.F., R.S. Sabi and O.T. Adedayo (2018b). Toxicological evaluation of graded levels of freshly harvested bamboo (*Bambusa arundinacea*) and Tridax (*Tridax procumbens*) leaves on blood chemistry of rabbits. Nig. J. Anim. Prod. 45(1), 183-197

Antwi-Boasiako, C., G.Y. Coffie and N.A. Darkwa (2011). Proximate composition of the leaves of *Bambusa ventricosa*, *Oxytenanthera abyssinica* and two varieties of *Bambusa vulgaris.* Sci. Res. Essays. 6 (34): 6835-6839.

AOAC (2005). Association of Official Analytical Chemist Official Methods of Analysis. Association of Official Analytical Chemists 18th ed. Gaithersburg USA, AOAC Press P 1250 – 1255.

Asaolu, V.O., R.T. Binuomote, J.O. Akinlade, O.J. Oyelami and K.O. Kolapo (2011). Utilization of *Moringa oleifera* fodder combinations with *Leucaena leucecophala* and *Gliricidia sepium* fodders for West African Dwarf Goats. Int. J. Agri. Res. 6: 607 – 619

Aye, P.A. and M.K. Adegun (2013). Chemical Composition and some functional properties of Moringa, Leucaena and Gliricidia leaf meals. Agric. Biol. J. N. Am. 4(1): 71-77

Ayoola, G.A., H.B. Coker, S.A. Adesegun, A.A. Adepoju-Bello, K. Obaweya, E.C. Ezennia and T.O. Atangbayila (2008). Phytochemical screening and antioxidant activities of some selected medicinal plants used for malaria therapy in southwestern Nigeria. Trop. J. Pharm. Res. 7:1019–1024.

Ayssiwede, S.B., A. Dieny, C. Chrysostome, W. Ossebi, J.L. Hornick and A. Missohon (2010). Digestibility and metabolic utilization and nutritional value of *Leucaena leucocephala* (Lam.) leaves meal incorporated in the diets of indigenous Senegal chickens. Int. J. Poultry Sci. 9:767-776.

Barakat, M.Z., S.K. Shehab, N. Darwish and E.I. Zahermy (1973). Determination of Ascorbic Acid from plants. Anal. Biochem. 53: 225-245.

Cooper, S.M. and N. Owen-Smith (1985). Condensed tannins deter feeding by browsing ruminants in a South African Savannah. Oecologia, 67:142 – 146

Cowieson, A.J., J.P. Ruckebusch, I. Knap, P. Guggenbuhl and F. Fru-Nji (2016). Phytate-free nutrition: A new paradigm in monogastric animal production. Anim. Feed Sci. Technol. 222: 180-189

Enri, S. R., M. Probo, M. Renna, E. Caro, C. Lussiana *et al*. (2020). Temporal variations in leaf traits, chemical composition, and *in vitro* true

digestibility of four temperate fodder tree species. Anim. Prod. Sci. 60: 643-658

Harbone, J.B. (1973). phytochemical Methods. London. Chapman and Hall Ltd.: 49-188.

Hogarth, N. and B. Belcher (2013). The contribution of bamboo to household income and rural livelihoods in a poor and mountainous county in Guangxi, P. R. China. Int. Forestry Rev. 15(1):71-81

Igile, G.O., I.A. Iwara, B.I.A. Mgbeje, F.E. Uboh, and P.E. Ebong (2013). Phytochemical, proximate and nutrient composition of *Vernoniacalvaona* Hook (Asterecea): A green-leafy vegetable in Nigeria. J. Food Res. 2: 1-11

Isah, O.A., P.O. Fayemi, M.B. Gazaly, and R.Y. Aderinboye (2012). Nutritional characteristics of four browse plants consumed by free-ranging ruminants in Western part of Nigeria. Afr. J. Agric.Res. 7(12): 1944-1949.

Mada, S.B., A. Garba, A. Mohammed, A. Olagunju, and H.A. Mohammed (2012). Effects of Boiling and Roasting on Antinutrients and Proximate Composition of Local and Some Selected Improved Varieties of *Arachishypogaea*L (Groundnut). Int. J. Food Nutr. Safety, 1(1): 45-53.

Makkar, H.P.S. (2003). *Quantification of Tannins in Tree and Shrub Foliage*, (Dordrecht, the Netherlands, Kluwer Academic)

Mlambo, V., U. Marume and C.S. Gajana (2015). Utility of the browser's behavioural and physiological strategies in coping with dietary tannins: Are exogenous tannin-inactivating treatments necessary? S. Afr. J. Anim. Sci. 45(5), 441-451

Naumann, H. D., O.L. Tedeschi, E.W. Zeller, and F.N. Huntley (2017). The role of condensed tannins in ruminant animal production: advances, limitations, and future directions. Rev. Bras. de Zootec. 46(12): 929-949

Nwosu, J.N. (2010). Effect of Soaking, Blanching and Cooking on the Anti-nutritional Properties of Asparagus Bean (*Vigna Sesquipedis*) Flour. Nature and Science, 8(8): 163-167

Nyamukanza, C.C. and A. Sebata (2020). Effect of leaf type on browse selection by free-ranging goats in a southern African savanna. PLoS ONE 15(11): e0242231.

Obadoni, B.O. and P.O. Ochuko (2001). Phytochemical studies and comparative efficacy of the crude extracts of some homostatic plants in Edo and Delta States of Nigeria. Global J. Pure Appl. Sci. 8b: 203 – 208.

Odouzo, P.C. and T.A. Adegbola (1992). Chemical composition, nutrient intake and digestibility of some forage hays fed to rabbit. J. Anim. Prod. Res. 12:49-54

Onunkwo, D.N. and O.S. George (2015). Effects of *Moringa oleifera* leaf meal on the growth performance and carcass characteristics of broiler birds. J. Agric. Vet. Sci. 8: 63-66.

Onwuka, C.F.I. (1996). Plant phytates, oxalates, and their effects on nutrient utilization by goat. Nig. J. Anim. Prod. 23(1): 53 – 60.

Rathmod, J.D., L.N. Pathak, G.R. Patel,N.P. Jivani, and M.N. Bhatt (2011). Phytophamacological properties of *Bambusa arundinaceae* as a Potential Medicinal Tree: An Overview. J. Appl. Pharm. Sci. 1(10):27-31.

Raw Materials Research and Development Council (RMRDC) (2006). Taxonomy of Bamboos in Nigeria. Report of Experts Committee Submitted to the Raw Materials Research and Development Council, Abuja.

Sallau, A.B., S.B. Mada, S. Ibrahim, and U. Ibrahim (2012). Effect of boiling, simmering and blanching on the anti-nutritional content *of Moringa oleifera l*eaves. Int. J. Food Nutr. Safety 2(1):1-6.

Samtiya, M., R.E. Aluko and T. Dhewa (2020). Plant food anti-nutritional factors and their reduction strategies: an overview. Food Prod. Process. and Nutr. 2, 6

Sarangthem, K. and N. Singh (2013). Fermentation decreases the anti-nutritional content in bamboo shoots. Int. J. Current Microbiol. Appl. Sci. 2(11): 361-369.

SAS (2010). SAS Systems for Windows 9.0. SAS Institute Inc., Cary, NC, USA.

Szabo, M.R, C. Iditoiu, D. Chambre, and A.X. Lupea (2007). Improved DDPH determination for Antioxidant Activity Spectrophotometric Assay. Chem. 61(3): 214-216

Thapa, N., J. Lamichhane and D. Gauchan (2018). Phytochemical, antioxidant, antimicrobial and micropropagation study of Bambusa species. Int. J. Res. 5(21); 77-88

Ullah, A., S. Munir, S. L. Badshah, N. Khan, L. Ghani, B. G., Poulson, A.H. Emwas and M. Jaremko (2020). Important Flavonoids and Their Role as a Therapeutic Agent. Molecules, 25(22), 5243.

Van Soest, P.J., J.B. Robertson and B.A. Lewis (1991). Methods for dietary, fiber, NDF and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3597

Wheeler, E.L. and R.E. Ferrel (1971). A method for phytic acid determination in wheat fractions. Cereal Chem. 48: 312 – 320.