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Proximate Composition, Anti-Nutrients and Crude Fibre Fractions of Selected Leaves Fed to Ruminants

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Abstract:

This study was carried out to determine the chemical composition of leaves namely: pineapple *(Ananascomosus)*, cabbage *(Brassicaoleraceae) (waste)*, carrot *(Daucuscarota)*, pawpaw *(Caricapapaya)*, orange *(Citrussinensis)*, mango *(Magniferaindica)* and avocado (*Persea americana*) leaves fed to ruminants by local livestock farmers. All parameters under proximate analysis were significantly affected ($P<0.05$), all parameters for anti-nutrients except phytate were significantly affected ($P<0.05$). Likewise, all parameters for crude fibre fractions except cellulose and Acid detergent lignin (ADL) were significantly affected ($P<0.05$).Dry matter ranged from 95.36% (orange leaves) – 96.36% (cabbage waste). Pawpaw leaves had the least ash value of 14.05% while orange leaves had the highest ash value of 16.63%. Lipid ranged from 2.67% (carrot leaves) – 3.87% (avocado leaves), protein: 26.56% (pineapple leaves) – 27.11% (cabbage waste), fibre: 6.04% (cabbage waste) – 7.91% (orange leaves) and carbohydrate from 40.495% (orange leaves) – 46.10% (cabbage waste).For anti-nutrients, saponin ranged from 0.67% (pawpaw leaves) – 2.13% (orange leaves), tannin: 5.11% (pineapple leaves) – 7.22% (cabbage waste),phytate: 0.003mg/100g (carrot leaves) – 0.006mg/100g (pineapple leaves), oxalate: 0.87% (pawpaw leaves) - 2.41% (pineapple leaves), and flavonoid from 3.57% (pineapple leaves) – 4.26% (orange leaves).For crude fibre fractions, cellulose ranged from 10.75% (carrot leaves) – 11.68% (pineapple leaves), hemicellulose: 7.75% (pawpaw leaves) – 9.11% (pineapple leaves), NDF: 10.67% (pineapple leaves) – 11.73% (avocado leaves), ADF: 7.14% (pineapple leaves) – 8.45% (orange leaves) and ADL from 1.71% (cabbage leaves) – 2.22% (mango leaves).Experimental results proved positive, thus selected leaves can be incorporated into ruminants' diet (and as supplementary feeding) during periods of scarcity. This reduces cost and high competition for conventional feedstuffs between man and ruminants.

Keywords:

Proximate Composition, Anti-Nutrients, Crude Fibre Fractions, Leaves, Ruminants

1. Description of Problem

Ruminant production in developing African countries is often characterized with low level of efficiency which has been attributed to unfavourable climate, disease prevalence and feed shortage especially in dry seasons. The first two factors tend to encourage adoption of intensive ruminant farming system which can further aggravate the problem of inadequate feed supply [1].

The low nitrogen content of dry season fodder usually confers severe nutritional stress on ruminants. Dry seasons result in a rapid decline in the quality and quantity of forages leading to low intake and digestibility with resultant poor performance. The cost of feed accounts for about 60% of the total intensive production cost compared to 40% value under extensive production system [2]. A large reduction in feed cost is achievable by the use of unconventional feed resources such as fodder or shed tree leaves to bring about improvement in ruminant production efficiency in the resource poor developing countries like Nigeria [1].

A number of browse plants worldwide serve as alternative feedstuffs for livestock [3,4]. They have abundant biomass and are available all year round. They are considered palatable, highly digestible and as a result improved animal performance [5]. However, most of these forages contain anti-nutritional substances which might affect their digestibility and availability of nutrients.

The rising trend in tree planting can be mutual and beneficial to both small and large ruminants, and the environment at large. Leaves of trees can be used to feed goats and sheep as protein supplements all year round while wastes accruing from the animals can as well be used as organic matter for trees [6].

In the context of increasing human population in developing countries, decreasing land availability for forage crop production has an increasing dependence of ruminants on low quality basal feed resources and competition for the available protein meals. Trees foliage are increasingly seen as potential protein and energy supplement to increase productivity by ruminants [7].

The best of animal production have not been fully attained in Nigeria because of the constraints mentioned. As population increases, the availability of conventional feedstuffs for animal feeding is decreasing. The use of tree leaves as feedstuff will help in bridging the competition gap, thus the need to know and have recent information on the chemical composition for the selected leaves which ordinarily would have been eliminated as sheer waste, and to see if climate change would have affected the nutrient composition over time. Objectives are to determine the proximate composition, anti-nutrients and crude fibre fractions of the selected leaves.

2. Materials and Methods

2.1. Sources of the Selected Leaves

The leaves of pineapple, cabbage waste, carrot were obtained from the vegetable market, Farin Gada, Jos, mango and orange leaves from the Federal College of Forestry, Jos, pawpaw leaves from the Students Village Hostel, University of Jos, and avocado leaves from Odus, Jos.

2.2. Chemical Analysis

Fresh selected leaves were washed using clean water, allowed to drain, some chopped into smaller bits using a knife, oven dried using a hot air oven and digital dryer at 60°C to avoid denaturing of nutrients (except pawpaw leaves which was shade-dried). Samples were crushed into fine powder using mortar and pestle (except pineapple leaves which was crushed using an electric blender), sieved and package in air-tight and transparent container labeled accordingly for analyses. The analyses was carried out at the Chemistry Laboratory, Federal University Lokoja, Kogi State, Nigeria.

2.3. Determination of Proximate Composition anti-nutrients and Crude Fibre Fractions

This entails the determination of moisture (from which dry matter is obtained), fat, ash, crude fibre according to [8]. Carbohydrate was determined according to [9] and protein was determined by the Kjedahl method (all expressed in percentage %)

2.4. Determination of Anti-nutrients

Saponin was determined according to [10], tannin by [11], phytate by [12], oxalate by [13] and flavonoid by methods described by [14].

2.5. Determination of Crude Fibre Fractions

Cellulose, hemicelluloses, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined by the method of [8].

3. Results and Discussion

Table 1 shows the experimental results for the proximate composition of the selected leaves.

Pineapple leaves from the experiment revealed a DM value of 95.85%, a contrast with 12.91% and 21.84% provided by [15,16] respectively. Ash of 14.22% was observed, this is higher than the value 6.21%, 5.7% and 5.0% according to [16,17,18]. This probably indicates that the soil on which the pineapple fruit (from which pineapple leaves were obtained) was cultivated has high mineral content. The lipid was 3.41%, higher than 2.80% [18] and almost double of the values 1.18% and 1.8% provided by [16,17] respectively. The protein value of 26.56% was greater than the values 5.08%, 7.3% and 9.0% [16,17,18] accordingly. Likewise, fibre of 6.23% was lower – a sharp contrast to the value 11.57%, 48.7% and 24.0% reported by [16,17,18].

Cabbage waste had DM of 96.36% in line with 94.6% and 90.3% reported by [19,20] respectively, while [18] reported a lower DM of 20.0%. Ash obtained was 14.54% and correlated positively with 15.9% and 15.4% [19,20]; the value 27.2% provided by [18] was almost double of the value in the present study. Lipid was found to be 2.83%, while [18,19,20] reported it as 3.5%, 11.1% and 28.2% respectively. Protein of 27.11% was obtained which is very close to the value 28.2% according to [20]; other reported values are 20.0%, and 23.0% according to [18,19]. The fibre content of 6.04% was obtained, thus lower than 10.3%, 11.4% and 13.0% according to [18,19,20].

Carrot leaves had DM of 96.28%, close to 95.5% by [21]. Ash recorded was 14.71%, which is close to 15.00% [22]. However, the value 21.16% and 18.00% by

[21,23] were higher than the ash value of the present study. Lipid was evaluated to be 2.67%, very close to 2.80% by [21] but quite lower than 3.37% by [22]. Protein of 27.05% was obtained, this is higher than the value 9.35%, 20.27% and 11-12% presented by [21,22,23] respectively. The value of 6.23% was obtained for fibre, a value lower than 7.8% and 17.00% by [21,23] respectively. Carbohydrate in carrot leaves was evaluated to be 45.92%, which is lower than 61.36% by [22].

Also, pawpaw leaves was evaluated with a DM of 95.89%, quite higher than 89.60% provided by [24]. Ash was found to be 14.05% which is higher than 11.0% and 11.4% according to [25,26]. Lipid had the value 3.13%, this is quite close to 3.5% [24], but higher than 0.8% and 0.00% by [25,26] respectively. Protein obtained was 26.65% while 13.1%, 32.6% and 33.4% were reported by [24,25,26] respectively. Its fibre content had the value of 7.19%, close to 7.30% according to [25], but lower than 14.1% provided by [26]. Carbohydrate was 44.93%, higher than 38.4% reported by [26].

Mango leaves had DM of 96.29%, quite close to the value 100% according to [18]. Ash value of 14.15% was higher than 5.4%, 12.61% and 8.24% provided by [18,27,28] respectively. Fibre content of 6.85% was evaluated, however, [18,28] reported crude fibre values to be 2.8% and 10.60% respectively. Carbohydrate of 44.98% was obtained, however, this is lower than 60.61% according to [28]. Orange leaves had the DM, ash, lipid, protein, fibre and carbohydrate content of 95.35%, 16.63%, 3.63%, 26.71% 7.91% and 40.495% respectively.

Avocado leaves had DM of 95.96%. its ash content was 15.64%, which is greater than 5.6% and 3.4% reported by [28,29] respectively. The lipid content of 3.87% is slightly higher than 3.84% [28], but lower than 6.5% [29]. Likewise, protein obtained was 27.6% [28,29] respectively. Fibre was evaluated as 6.10% which is lower than 6.58% and 8.5% as reported by [28,29] respectively.

Table 1. *The Proximate Composition of Selected Leaves Fed to Ruminants.*

Parameters	Pineapple leaves	Cabbage leaves	Carrot leaves	Pawpaw leaves	Orange leaves	Mango leaves	Avocado leaves	LOS
DM (%)	95.85^{d}	96.36^{a}	96.28^{b}	95.89^{cd}	95.35^{e}	96.29^{ab}	95.96^{c}	**
Ash (%)	14.22^{e}	14.54^{d}	14.71^{c}	14.05^{f}	16.63^{a}	14.15^{ef}	15.64^{b}	**
Lipid (%)	3.41^{d}	2.83^{f}	2.67^{g}	3.13^{e}	3.63^{c}	3.72^{b}	3.87^{a}	**
Protein (%)	26.56^{d}	27.11^{a}	27.05^{a}	26.65^{bc}	26.71^{b}	26.63^{cd}	27.07^{a}	**
Fibre (%)	6.23^{d}	6.04^{e}	6.23^{d}	7.19^{b}	7.91^{a}	6.85^{c}	6.10^{e}	**
CHO (%)	45.43^{ab}	46.10^{a}	45.92^{a}	44.93^{b}	40.50^{d}	44.98^{b}	42.89^{c}	**

*Key: Key: * = Significant at P<0.05, ** = Highly Significant at P<0.01, NS = Non Significant, DM = Dry matter, CHO = Carbohydrate , LOS = Level of Significant*

Pineapple leaves in this study contains 2.02% saponin, which is lower than 3.10% reported by [30]. Tannin was evaluated as 5.11% which is in line with the value 5.02% [30]. (Table 2)

Saponin, tannin, phytate, oxalate and flavonoid content in cabbage waste were evaluated to be 1.83%, 7.22%, 0.005mg/100g, 2.32% and 4.075% respectively.

Carrot leaves also have saponin, tannin, phytate, oxalate and flavonoid constituents evaluated to be 0.85%, 5.15%, 0.003mg/100g, 1.36% and 4.14% respectively. Cabbage wastes and carrot leaves have scarcely any information provided by other authors regarding the selected anti-nutrients.

Pawpaw leaves had saponin of 0.67% (6.7mg/ml), it is higher than 3.57mg/ml according to [24]. Tannin was 5.22%, while [24,31] reported the values 2.656% and 0.31% respectively. Phytate and oxalate levels from the experiment are 0.005mg/100g and 0.87% respectively, and have no corresponding values from the other authors. It could be that little or no research have been carried out to determine phytate and oxalate in pawpaw leaves. However, the 3.61% reported as the value for flavonoid is higher than 0.87% (866.53mg/100g) as reported by [31].

Orange leaves had the value 2.13%, 5.45%, 0.004mg/100g, 2.12% and 4.26% for saponin, tannin, phytate, oxalate and flavonoid respectively.

Mango leaves in the study had saponin of 1.64% which is higher than 1.24% and 0.0032% (3.22mg/100g) according to [28,31] respectively. Tannin had the value 6.13% which is greater than 1.38% [28]. Phytate and oxalate values were found to be 0.0055mg/100g and 2.15% respectively.

Avocado leaves had saponin of 1.38%, which is in line with 1.33% [28], but disagrees with 0.61% according to [29]. Tannin was evaluated to be 6.13%, while [28] provided the value 0.51%. Phytate was revealed to be 0.006mg/100g in the study; however, [29] reported it as 51.7mg/100g. Oxalate was found to be 2.15% in the experiment, whereas, there are scarcely any value for oxalate in avocado leaves by other authors. Finally, flavonoid was evaluated to be 4.24%, which is higher than 0.44% and 0.78% by [28, 29] respectively.

Table 2. *The Anti-Nutritional Factors of Selected Leaves Fed to Ruminants.*

Parameters	Pineapple leaves	Cabbage leaves	Carrot leaves	Pawpaw leaves	Orange leaves	Mango leaves	Avocado leaves	LOS
Saponin (%)	2.02^{ab}	1.83^{ab}	0.85^{d}	0.67^{d}	2.13^{a}	1.64^{bc}	1.38^{c}	**
Tannin (%)	5.11^{e}	7.22^{a}	5.15^{e}	5.22^{d}	5.45^{c}	6.13^{b}	6.13^{b}	**
Phytate (mg/100g)	0.006	0.005	0.003	0.005	0.004	0.0055	0.006	NS
Oxalate (%)	2.41^{a}	2.32^{a}	1.36^{b}	0.87^{c}	2.12^{a}	2.15^{a}	2.15^{a}	**
Flavonoids(%)	3.57^{c}	4.075^{b}	4.14^{b}	3.61^{c}	4.26^{a}	4.24^{a}	4.24^{a}	**

*Key: * = Significant at P<0.05, ** = Highly Significant at P<0.01, NS = Non Significant, LOS = Level of Significant*

The experiment carried out revealed that pineapple leaves had cellulose of 11.68%, a sharp contrast to 66.2% and 43.53% according to [33,34] respectively. Hemicellulose was evaluated to be 9.11% and it is still lower than the values 19.5% and 21.88% [33,34]. The NDF and ADF values are 10.67% and 7.14% respectively. However, NDF and ADF values for pineapple leaves were scarcely provided by other authors. The value for ADL in the present study is 1.89% which is also lower than 4.2% and 18.33% by [33,34] respectively. (Table 3)

Cabbage waste have cellulose of 11.13% which is lower than the value 13.7% and higher than 7.87% reported by [23,35] respectively. Hemicellulose was 8.62% which is lower than 11.1% [34] but higher than 3.09% [35]. The NDF value of 11.30% in the present study is close to 12.66% according to [35] while [36] gave the NDF value to be 18.9%. The ADF of 7.16% was obtained; this is lower than the 22.6%, 9.56% and 16.9% as reported by [23,35,36]. The ADL value of cabbage waste was evaluated to be 1.71% which is almost the same as 1.70% reported by [35].

Carrot leaves were evaluated to contain cellulose, hemicellulose, NDF, ADF and ADL of 10.75%, 8.76%, 11.18%, 7.37% and 1.86% respectively. Likewise, pawpaw had 11.26%, 7.75%, 11.65%, 8.13% and 1.72% for cellulose, hemicelluloses, NDF, ADF and ADL respectively.

In like manner, orange leaves contain cellulose, hemicelluloses, NDF, ADF and ADL of 11.21%, 7.82%, 11.43%, 8.45% and 1.73% respectively.

Cellulose, hemicellulose, NDF, ADF and ADL values in avocado leaves are 11.54%, 7.87%, 11.73%, 7.64% and 1.87% respectively as crude fibre fractions. For carrot leaves, pawpaw leaves, orange leaves and avocado leaves, there are scarcely values of crude fibre fractions by other authors. This makes this research relevant as it has helped in providing values for parameters that are scarcely researched into.

Mango leaves contain cellulose and hemicellulose of 11.14% and 7.82% respectively. The NDF value in the present study is 11.57% and this is less than 35.32% according to [27].

Table 3. *The Crude Fibre Fraction of Some Selected Leaves Fed to Ruminants.*

Parameters	Pineapple leaves	Cabbage leaves	Carrot leaves	Pawpaw leaves	Orange leaves	Mango leaves	Avocado leaves	LOS
Cellulose (%)	11.68	11.13	10.75	11.26	11.21	11.14	11.54	NS
Hemicellulose (%)	9.11^{a}	8.62^{b}	8.76^{b}	7.75^{c}	7.82^{c}	7.82^{c}	7.87^{c}	**
NDF (%)	10.67^{e}	11.30^{cd}	11.18^{d}	11.65^{a}	11.43^{bc}	11.57^{ab}	11.73^{a}	**
ADF (%)	7.14^{e}	7.16^{e}	7.37^{de}	8.13^{ab}	8.45^{a}	7.84^{bc}	7.64^{cd}	**
ADL (%)	1.89	1.71	1.86	1.72	1.73	2.22	1.87	NS

*Key: NDF= Neutral Detergent Fibre, ADF= Acid Detergent Fibre, ADL= Acid Detergent Lignin, * = Significant at P<0.05, ** = Highly significant at P<0.01, NS = Non significant*

4. Conclusion and Applications

The study clearly reveals that the selected leaves contain vital nutrients that can be used as animal feedstuffs especially during dry seasons to supplement ruminant feeding instead of being allowed to litter the environment or be burnt as a means of eliminating what is considered “waste”.

a. Carbohydrate is one of the chief sources of energy required by ruminants to carry out metabolic, maintenance and production function. Reasonable amount of carbohydrates are supplied by the tree foliage (and cabbage waste) to met energy levels.

b. Anti-nutrients are always present in feedstuffs of plant origin. Though some may be beneficial or slightly not harmful to the ruminants, care must be taken not to feed ruminants in excess, else accumulated anti-nutrients result in deleterious effects. Feedstuff with appreciable levels of flavonoid can be incorporated into feeds to serve as feed additive thus increasing efficiency and usefulness of the feed material. The feed industry need to look into this.

c. The crude fibre fractions determined are of permissible levels in the feedstuffs considered. Care must be taken that ruminants do not feed on excessively high fibrous feeds.

d. More recent values on the chemical composition of leaves as provided should be considered for use in research (and feed formulation) instead of the values since some values have changed due to climate change overtime.

e. Animal nutritionists or feed formulators should explore how the selected leaves in this study can be incorporated into ruminants' diet for better efficiency, performance and productivity.

f. Livestock farmers should be enlightened on the utilizations of tree foliage (and cabbage waste).

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Author Contributions

U.O. and A.O.O.; carried out the practical/ part of funding, U.O.; J.S.L., D.O.O; Supervision/ part of funding/ Formal analysis/ Writing – review and editing, E.A.T.; part of funding

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