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

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Abstract:

This study was undertaken to determine the chemical composition of six common peels fed to ruminants namely: Irish potatoes (*Solanum tuberosum*), watermelon (*Citrullus lanatus*), sweet orange (*Citrus sinensis*), cucumber (*Cucumis sativus*), pineapple (*Ananas comosus*), pawpaw (*Carica papaya)* and lettuce (*Lactuca sativa*). These were purchased from fruit and vegetable retailers in Jos, Plateau State. The results for proximate composition are as follows: dry matter ranged from 95.75% (pawpaw peels) to 96.25% (watermelon rind), carbohydrate from 41.95% (pawpaw peels) to 45.70% (cucumber peels), fibre from 6.07% (cucumber peels) to 7.65% (pineapple peels), protein from 25.46% (sweet orange peels) to 26.66% (watermelon rind), lipid from 3.01% (lettuce) to 4.00% (watermelon rind) and ash from 13.97% (cucumber peels) to 16.71% (Irish potato peels). For antinutrients, saponin ranged from 0.867% (cucumber peels) to 2.53% (watermelon rind), tannin from 5.09% (cucumber peels) to 6.37% (lettuce), phytate from 0.003mg/100g (sweet orange peels and pawpaw peels) to 0.007mg/100g (watermelon rind), oxalate from 1.08% (cucumber peels) to 2.43% (watermelon rind) and flavonoid from 3.66% (Irish potato peels) to 4.37% (cucumber peels). Also, crude fibre fractions which include cellulose ranged from 10.81% (watermelon rind) to 12.02% (pineapple peels), hemicellulose from 7.73% (watermelon rind) to 9.24% (cucumber peels), NDF from 10.72% (lettuce) to 12.13% (sweet orange peels), ADF from 7.63% (Irish potato peels) to 9.13% (sweet orange peels) and ADL from 1.71% (cucumber peels) to 2.13% (watermelon rind).All parameters under proximate composition were significantly affected except protein, all parameters under antinutrients were significantly affected except phytate and flavonoid, and all parameters under crude fibre fractions were significantly affected ($P<0.05$). The selected samples are recommended for ruminant feeding at permissible levels or quantities.

Keywords:

Ruminants, Proximate Composition, Antinutrients, Crude Fibre Fractions, Peels

1. Description of the Problem

Due to the high competition between man and livestock for conventional food, scientific technologies have been developed and implemented over the past decades to bridge the gap, and make food/feed available to humans and livestock; however, the world is still searching for better ways to feed humans and livestock in terms of finding new potential food/feed stuffs as accurate methods of improvement and evaluation of their nutritive value [1]. While there is an increasing demand for livestock products in most developing countries, many of these countries are experiencing a feed deficit, unable to adequately source sufficient animal feed materials to raise healthy (and productive) livestock and poultry. Limited arable land, scarce water resources, competition between human food-animal feed, as well as global warming and its associated climate variations have imposed a mammoth threat to the sustainability of the animal feed production structure. In most countries like Nigeria, food shortage is becoming evident as a result of population growth, competition for fertile land and poverty [2].

The need to explore alternative means of using non-conventional feedstuff such as crop by-products as a way of escaping high cost of feeding and improving ruminants' productivity is paramount. Peels are provided as supplementary feedstuffs to nourish ruminants especially in seasons when the natural vegetation (the mainstay of feeding ruminants in Nigeria) are scarce. Thus, the need for this study. Also, it is vital to provide recent nutrient composition values for the selected feedstuffs to see if climate change have affected the chemical composition of selected feedstuffs over time. The objectives of the study are to determine the proximate composition, anti nutrients and crude fibre fractions present in the selected samples.

2. Materials and Methods

Fresh samples of peels of Irish potatoes, watermelon (rind), sweet orange, cucumber, pineapple, lettuce and pawpaw were purchased from retailers in Jos, Plateau State. These were washed to remove dust and debris. After draining, they were chopped into bits, oven-dried at 60 °C, cooled and crushed into powder using mortar and pestle. Crushed samples were sieved to obtain a fine-textured (smooth) powder, packaged in clean transparent air-tight containers, coded (labelled) accordingly, wrapped and sent to the Chemistry Laboratory, Federal University Lokoja, Kogi State, Nigeria for chemical analysis.

Determination of Proximate Composition, Anti nutrients and Crude Fibre Fractions

Proximate composition was carried out according to [3] for moisture, fat, ash and crude fibre, carbohydrate was determined according to [4] and protein by the Kjedahl method. For anti nutrients, saponin was determined according to the procedure of [5], tannin by [6], phytate by [7], oxalate by [8] and flavonoid by methods described by [9]. The method of [3] was used to obtain values for parameters such as cellulose, hemicellulose, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL).

Experimental Design and Layout

A completely randomized design (CRD) was used for this study.

Statistical Analysis: Data collected were subjected to one-way analysis of variance (ANOVA) and location of sampling was blocked or used as covariant in the final analysis. The significant differences in means were separated using Duncan Multiple Range Test contained in SPSS package (version 20).

3. Results and Discussion

Table 1. *Proximate Composition of Selected Peels Fed to Ruminants.*

Parameters	IPP	WMP	SOP	CUP	PIP	L	PAP	LOS
DM (%)	95.79^{d}	96.25^{a}	96.17^{b}	95.97^{c}	95.95^{c}	95.79^{d}	95.75^{d}	**
Ash (%)	16.71^{a}	16.61^{a}	15.68^{c}	13.97^{e}	15.15^{d}	16.42^{ab}	16.15^{b}	**
Lipid (%)	3.86^{ab}	4.00^{a}	3.75^{ab}	3.67^{b}	3.45^{b}	3.01^{c}	3.86^{ab}	**
Protein (%)	26.57^{a}	26.67^{a}	25.46^{a}	26.56^{a}	26.55^{a}	26.63^{a}	26.66^{a}	NS
Fibre (%)	6.16^{c}	6.17^{c}	6.23^{c}	6.07^{a}	7.65^{d}	7.13^{b}	7.13^{b}	**
CHO (%)	42.43^{b}	42.80^{b}	45.05^{a}	45.70^{a}	43.15^{b}	42.60^{b}	41.95^{b}	**

Key: IPP= Irish potatoes peels, WMP= Water melon peels, SOP = Sweet orange peels, CUP=Cucumber peels, PIP= Pineapple peels,

*L= Lettuce, PAP= Pawpaw peels, DM= Dry Matter, CHO= Carbohydrate, LOS= List of Significant, **= Highly significant and NS= Non-significant*

3.1. Discussion for Proximate Composition of Selected Samples

For Irish potato peels, the dry matter (DM) from the results obtained was 95.79%, a value greater than 90.03% according to [10], and also greater than 88.80% reported by [11]. Carbohydrate (CHO) was found to be 42.43%, this is lower than 64.47% according to [11]; fibre was evaluated to be 6.16%, quite higher than 5.27% reported by [10]; protein obtained was 26.57%, which is almost double of the value 13.52% as provided by [11]. Its lipid content was discovered to be 3.86%, greater than 0.23% as reported by [10], ash was 16.71%, higher than 7.11% and 7.56% according to [10,11] respectively.

Watermelon peels (rind) had DM of 96.25% from the study, this is higher than 93.65% presented by [12]; CHO was evaluated to be 42.80%, this is greater than 5.22% as documented by [12] and less than 67.804% as reported by [13]. Likewise, fibre content reveals the value 6.17%, greater than 0.23% and 2.40% according to [12,13] respectively. Protein obtained was 26.67%, greater than 0.53% reported by [12]. Lipid accounts for 4.00% from the results.

Sweet orange peels had fibre content of 6.23% which is greater than 4.20% and 3.78% presented by [14,15] respectively. Its protein content was found to be 25.46%, also greater than 4.60% and 6.50% as reported by [14,15] respectively. Lipid was evaluated to be 3.75%, quite higher than 3.30% according to [14]; ash revealed the value 15.68%, greater than 3.90% and 5.93% from the results of [14,15] respectively.

Cucumber peels had DM of 95.95% which is close to 96.56% provided by [12]; fibre content of 7.65% was greater than 0.27% and 1.56% reported by [12,16] accordingly. In like manner, lipid and ash were evaluated to be 3.45% and 15.15% respectively from the study, while [12] presented lipid and ash values as 0.14% and 0.33% respectively.

Furthermore, pineapple peels had DM of 95.97%, greater than 14.22% and 91.70% according to [16,17] respectively; CHO was evaluated as 45.70% and fibre content of 6.07%, less than 7.61% provided by [17]; protein was 26.56% while lipid was 3.67%, a value quite higher than 3.49% [16]. Ash in pineapple peels revealed the value 13.97%, greater than 8.10% and 4.22%, reported by [16,17] respectively.

The DM obtained for lettuce was 95.79%, a far cry from 5.70% provided by [18]; CHO, fibre, protein, lipid and ash were evaluated to be 42.60%, 7.13%, 26.63%, 3.01% and 16.42% respectively.

Likewise, pawpaw peels had DM, CHO, fibre, protein, lipid and ash values of 95.75%, 41.95%, 7.13%, 26.66%, 3.86% and 16.15% from the study, while [14] presented the values of the parameters above as 3.80%, 4.20%, 3.20%, 3.20%, 3.60% and 2.50% respectively.

3.2. Discussion on Antinutrients Composition of the Selected Peels

Table 2. *Antinutrients Composition of the Selected Peels Fed to Ruminants.*

Parameters	IPP	WMP	SOP	CUP	PIP	L	PAP	LOS
Saponin(%)	2.15^{b}	2.53^{a}	2.14^{b}	0.867^{d}	2.17^{b}	1.75^{c}	2.13^{b}	**
Tannin(%)	5.13c	5.72^{b}	5.43 ^{bc}	5.09^{c}	5.19^{c}	6.37^{a}	5.21^{c}	**
Phytate(mg/100g)	0.0065 ^{a}	0.007^{a}	0.003^{a}	0.0055 ^{a}	0.004^{a}	0.0045 ^{a}	0.003 ^{a}	NS
Oxalate(%)	1.71 ^{bc}	2.43^{a}	1.92^{b}	1.08^{d}	2.14 ^{ab}	1.30 ^{cd}	1.99 ^{ab}	**
Flavonoid(%)	3.66^{a}	3.77^{a}	4.13^{a}	4.37^{a}	3.78^{a}	4.16^{a}	4.22^{a}	NS

Key: IPP= Irish potatoes peels, WMP= Water melon peels, SOP = Sweet orange peels, CUP=Cucumber peels, PIP= Pineapple peels,

*L= Lettuce, PAP= Pawpaw peels, DM= Dry Matter, CHO= Carbohydrate, LOS= List of Significant, **= Highly significant and NS= Non-significant*

From the experimental results, saponin, tannin and oxalate were evaluated to be 2.15%, 5.13% and 1.71% respectively, these are all greater than the values provided by [10] as 1.60%, 3.96% and 0.69% for the respective parameters. Its flavonoid content was found to be 3.66%.

Watermelon peels (rind) had saponin, tannin and oxalate values as 2.53%, 5.72% and 2.43%, these are greater than the values 0.69%, 0.68% and 0.89% respectively according to [14], and flavonoid content of 3.77% in the study.

Sweet orange peels had saponin of 2.14%, [14,19] reported saponin as 2.80% and 0.043% respectively. Tannin content was 5.43%, greater than 3.49% and 0.463% by [14,19] respectively. Phytate was evaluated to be 0.003mg/100g, lower than 1.29mg/100g and 0.077mg/100g provided by [14,19] respectively. Meanwhile, oxalate in sweet orange peels was found to be 1.92%, greater than 0.91% and 0.048% documented by [14,19] respectively.

Cucumber peels had saponin, tannin, phytate, oxalate and flavonoid of 0.86%, 5.09%, 0.0055mg/100g, 1.08% and 4.37% respectively.

Pineapple peels had saponin of 2.17%, greater than 0.18% and 1.90% according to [14,20] respectively. Likewise, tannin was evaluated as 5.19%, greater than 1.78% and 1.30% provided by [14,20]; phytate was 0.004mg/100g, while [14] reported the

value 0.52mg/100g. Oxalate had the value 2.14%, very close to 2.25% according to [14] and greater than 0.20% documented by [20]. Meanwhile, flavonoid was evaluated to be 3.78%, greater than 2.80% according to [20].

For lettuce, saponin, tannin, phytate, oxalate and flavonoid values were evaluated to be 1.75%, 6.37%, 0.0045mg/100g, 1.30% and 4.16% respectively from the study.

Finally, pawpaw peels revealed saponin, tannin, phytate and oxalate levels of 2.13%, 5.21%, 0.003mg/100g and 1.99% meanwhile, [14] evaluated the antinutrients stated above to be 0.18%, 4.70%, 1.92 mg/100g and 0.06% respectively. Flavonoid in pawpaw peels in the study had the value 4.22%.

3.3. Discussion on Crude Fibre Fractions of the Samples

Table 3. *Crude Fiber Fraction of the Selected Peels Fed to Ruminants.*

Composition (%)	IPP	WMP	SOP	CUP	PIP	L	PAP	LOS
Cellulose	11.72^{a}	10.81^{c}	11.07^{c}	11.10^{c}	12.02^{a}	11.75^{a}	11.42^{b}	**
Hemicellulose	9.12^{a}	7.73^{d}	8.63^{b}	9.24^{a}	8.45 ^{bc}	8.28^{c}	7.95^{d}	**
NDF	11.67^{c}	11.19^{d}	12.13^{a}	11.67^{c}	11.81^{b}	10.72^{f}	10.83^{e}	**
ADF	7.63^{f}	7.66^{f}	9.13^{a}	8.11^{d}	9.02^{b}	8.74^{c}	7.98^{e}	**
ADL	1.85^{b}	2.13^{a}	1.74^{a}	1.71^{b}	1.72^{b}	1.90^{ab}	1.93 ^{ab}	**

Key: IPP= Irish potatoes peels, WMP= Water melon peels, SOP = Sweet orange peels, CUP=Cucumber peels, PIP= Pineapple peels,

*L= Lettuce, PAP= Pawpaw peels, NDF= Neutral Detergent, ADF= Acid Detergent Fibre, LOS= List of Significance and **= highly significant.*

From the results, watermelon peels (rind) had cellulose and hemicellulose of 10.81% and 7.73% respectively. Its NDF was found to be 11.19%, greater than 8.00% reported by [18]. The ADF and ADL obtained was 7.66% and 2.13% respectively. Sweet orange peels from the study had cellulose and hemicellulose of 11.07% and 8.63% respectively. NDF was evaluated to be 12.13%, (slightly) higher than 11.90% and 2.00% reported by [18,21] respectively. Similarly, ADF and ADL values were found to be 9.13% and 1.74% respectively. Cucumber peels from the results had cellulose, hemicellulose, NDF, ADF and ADL values as 11.10%, 9.24%, 11.67%, 8.11% and 1.71%; in the same order of arrangement above, pineapple peels had the values 12.02%, 8.45%, 11.81%, 9.02% and 1.72%. There are scarcely any information on the crude fibre fractions of cucumber peels and pineapple peels from previous literature, thus, no comparisons are made. Lettuce revealed cellulose and hemicellulose of 11.75% and 8.28% respectively. The NDF value of 10.72% was obtained which is greater than 2.50% provided by [18]. ADF and ADL obtained in the present study reveals the values 8.74% and 1.90% respectively. Pawpaw peels had cellulose, hemicellulose, NDF, ADF and ADL of 11.42%, 7.95%, 10.83%, 7.98% and 1.93% respectively.

The similarities and differences in values discussed are attributed to processing method of samples used, the different analytical methods used by different laboratories and researchers, the variations that exist between available varieties of agricultural produce (from which peels were obtained), different stages of maturity of crop parts and the changes in climatic condition across different geographical locations over time.

4. Conclusions and Applications

The following observations were made and revealed from the study, from which it can be concluded that:

a. Fruit/tuber peels, and lettuce are endowned with an over-abundance of health nourishing compounds that positively affect ruminants' well-being and performance. However, antinutritional factors inherent in peels constantly fed to ruminants without mixing with any other feed, or if not properly managed with controlled dietary care, can interfere with the uptake of essential nutrients by blocking their synthesis or utilization by ruminants' digestive system.

b. The feedstuffs used are easily obtained from kitchen "wastes" and even food or fruit processing plants or industries. Since they are not needed directly in the food chain, the feed industry can easily procure them at little or no cost (depending on the quantity needed), harness the potentials therein and channel it to the feeding of ruminants. With this, financial problems encountered by farmers in developing countries due to high feed cost is reduced. This will be more effective when farmers are enlightened by animal nutritionists or extension workers (as the case may be) about the importance of peels fed to ruminants in the right proportion with other major feedstuffs.

c. Animal nutritionists can maximize the potentials in the samples considered to incorporate into feeds during feed formulation. This will promote feed efficiency, palatability and acceptability by ruminants- even ruminants know the right choice. Also, processing methods can be applied to reduce or eliminate the negative effects of antinutrients.

d. There is need for detailed research to be carried out and practically applied in this field of animal production because there are very limited literature related to this study (especially for antinutrients and crude fibre fractions). With this, sufficient information will be added to the body of knowledge, and animal nutritionists or feed formulators would be able to devise means of incorporating peels in the right proportion in ruminants' diet.

Conflicts of Interest

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

Author Contributions

U.O.; R.A.D and A.O.O.; carried out the practical/ part of funding, U.O.; J.S.L.; A.K.A; and M.Y.M; Supervision/ part of funding/ Formal analysis/ Writing − review and editing.

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