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ORIGINAL ARTICLE

Proximate analysis of selected agricultural waste for their nutritional potential

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ABSTRACT

Background: Global food insecurity is worsening as a result of the speedily expanding human population and this is taking a huge toll on the availability of feed for livestock. Alternative food sources are urgently required as livestock feeds to reduce the stern food competition between man and livestock. Agricultural waste may be able to provide cost-effective sources of nutrients. **Aim:** The study determines the proximate properties of agricultural waste for their possible use as raw material for animal feed. **Material and methods:** Consequently, 10 samples of agricultural waste were collected from locations in Edo state where the plants are cultivated in commercial quantities. Proximate analysis was performed on the samples using standard protocols to evaluate their nutritive potentials for utilization as feedstuffs for livestock feeds. The proximate properties of the agricultural waste were compared with plantain flesh (PF Auchi and PF Benin). **Results:** Significant variations exist among the samples ($p < 0.05$) with respect to their fat, protein, nitrogen free extract (NFE) and dietary fiber content. The following samples had highest proximate values; corn cob (moisture content at 17.38%), PP Usen (ash content at 7.58%), PP Benin (fat content at 7.20%), CHI Usen (fiber content at 12.70%), PP Auchi (protein content at 19.83%) and PF Benin (Nitrogen Free Extract (NFE) at 73.43%). Plantain peels had the closest proximate properties to plantain flesh. **Conclusion:** The results from the analysis show that the proximate properties of the wastes compare favorably with plantain flesh and will be suitable for livestock feeds production. The production of livestock feed from agricultural waste would also serve as an effective and attractive method to manage the waste.

Keywords: livestock, agricultural waste, nutrient, feeds.

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1 Introduction

Environmental contamination through waste generation is an inevitable activity of man. In recent times, these activities have become so complex and multidimensional that the quantity of by - products and unutilized resources has started mounting up at outrageous rates. In many instances, waste has exceeded the carrying capacity of the biosphere, resulting in the pollution of the air, water and land. The threat to the living systems, if not properly tackled, could be very overwhelming. For developing countries like Nigeria where proficiency in proper handling of waste is lacking, the consequences could be more devastating.

Waste arising from agricultural activities contributes significantly in the degradation of the environment. Agricultural processing results in the generation of about 0.3 ton (30%) of waste per every ton of agricultural product processed [1, 2], which is 15% of total waste and amounting to a global estimate of 998 million tons per annum [3, 4]. These wastes include spoiled fruits, vegetable wastes, cocoa husks, seeds, agricultural industry wastes, animal dung, fisheries refuse, plantain peels, cassava peels, yam peels, etc. In Nigeria, farmers are constrained by agricultural waste mismanagement due to inadequate knowledge about waste treatment coupled with the cost and pressure associated with waste disposal. Therefore, they ignorantly rid of waste using environmentally harmful and unsustainable methods, such as discarding in concentrated heaps around the farm areas to rot, at the backyards, road sides, outskirt of cities/towns, burning, dumping into storm drainage channels, creeks, lagoons and seas [5, 6]. The impact of these waste mismanagement threatens man's existence and degrades the environment. This has also led to proliferation of disease-causing organisms and the release of greenhouse gasses during decomposition [7, 8]. The lives of inhabitants around the polluted area are more endangered.

The abundance of agricultural waste coupled with their hostile environmental effects instigate the quest for their valuable and positive uses. Especially when around 335,200 (16.70%) persons die annually in Nigeria as a result of poor sanitation, water and hygiene related infection [9, 10]. Consequently, an organized, sustainable and systematic waste management policy in line with acceptable public protections practice is urgently needed. Maximizing the nutrient benefits of waste and recycling wastes is better than discarding or burning them. Agricultural wastes can be treated and managed for different purposes so as to maximize the benefit of nutrients in them. Furthermore, wastes are now fast changing to treasured resources [5] as they contain various nourishing, energetic and fertilizing properties [11] that are lost by various waste mismanagement methods used in Nigeria.

In this regard, waste utilization technologies that convert waste into useful products, treat waste in a manner that prevents them from degenerating the environment or brand waste into suitable resources for processing desired end-products is vital. Several methods employed in waste management such as land filling, pyrolysis/gasification, incineration, vermicomposting, aerobic and anaerobic digestion have been extensively studied and are challenged with some economic and environmental disadvantages [12, 13]. However, studies on proximate analysis of selected agricultural waste for their nutritional potential remains still largely unexploited. This information [14] is necessary to categorize agro waste according to their nutrient content and develop feeding guidelines. The different fractions of processed waste that will constitute a nutritionally balanced feed for target livestock, in line with the distinctiveness of the individual waste, can also be obtained. The information is also required to deliver products that are safe as livestock feeds as well as safe for humans to feed livestock with. It is on this note that the present study quest to determine the proximate properties of selected agricultural waste for their nutritional potentials. Moreover, the speedily expanding human population, resulting in scarcity of food and in turn spilling into a huge toil on the availability of livestock feeds, demands an urgent need to seek alternative food sources. Already, an estimated 11.70% of the world population are living in hunger [15]. In addition, an expected increase of the world population to over nine billion people by 2050 [16], could increase malnourishment of both humans and livestock [17] hence, waste conversion into feed is highly recommended. Livestock is one of the most important food resources of man. And to effectively address the issue of malnutrition, hunger, and famine, alternative sources of feeds for livestock must be developed, especially when supplementing silage and pasture with grains and protein concentrate as a way to boost livestock production is no longer sustainable [18] because of the stern competition of their uses as human food and livestock feeds. On this note, agricultural waste may be able to provide a cost-effective sources of livestock nutrition and also improve on protein/calorie supplies.

It is on this basis the study aims to determine the proximate analysis of selected agricultural waste for their nutritional potential. More-so, the study intends to compare the energy content and nutritional properties of these waste with plantain flesh.

2 Material and Methods

2.1 Samples collection and preparation

Fresh mature unripe plantain was obtained respectively from Auchi (Uchi market), Benin (Oluku market), Jattu market, Elele (along the express road) and Usen (from a farmer). Fresh mature ripe African pear were both obtained in Benin from two different sellers in Oluku market. Fresh mature ripe cocoa pods were both obtained in Usen from two different farmers. Also, fresh mature corn was obtained from a farmer in Elele. All the samples were collected within three days from Tuesday 23rd to Thursday 25th August 2022. The samples were washed with tap water, allowed to drain, air-dry and weighed. The edible part of the samples was separated and the weight of the wastes were taken again. Thereafter, the plantain flesh, the plantain peels, cocoa husk, African pear seeds and the corn cob were separately chopped into small pieces and dried in an oven at 50 °C until they all attain constant masses. After cooling, the seeds were milled into powder with a blender and stored in air-tight polythene bags before use.

2.2 Moisture content and dry matter determination

Moisture content was determined gravimetrically in accordance with the standard methods of the Association of Official Analytical Chemists [19] by the loss in weight that occurs when sample is dried in an oven to a constant weight. A 2 g each of samples were weighed into a clean dry silica dish and then dried in an oven for 65 °C for 36 hours until a constant weight is achieved. The percent moisture content (% MC) of the samples were calculated using the formula;

$$\%MC = \frac{(\text{Wt of sample+dish})\text{before drying} - (\text{Wt of sample+dish})\text{after drying}}{\text{Wt of sample before drying}} \times 100$$

Moisture free or dry matter (%DM) of the samples were obtained by subtracting moisture content from 100 using the formula; % DM = 100 - % Moisture.

2.3 Ash content determination

Ash content was assessed by placing 2 g of the samples in a pre-heated crucible and cremating in a muffle furnace at 650 ºC until whitish-grey ash is obtained (Method No. 930.05) [19]. The ash content (AC) of the samples were calculated using the formula;

$$\%AC = \frac{\text{Wt of Crucible} + \text{ash} - \text{Wt of Crucible}}{\text{Wt of sample}} \times 100$$

2.4 Crude fats determination

Crude fat was determined in accordance with the Soxhlet extraction method using petroleum ether as the extraction agent at 60–80 ºC (Method No. 930.09) [19]. A 2 g of each sample was weighed and wrapped in a filter paper. Then the filter paper and its content were loaded into the thimble compartment of the Soxhlet extractor. Thereafter, the thimble was placed in the refluxing unit of which about 300 mL anhydrous diethyl ether extraction solvent was placed and extraction was conducted at 50 ºC. After the extraction, the sample was placed in an oven at 65 ºC for four (4) hours, cooled in a desiccator and weighed again. The fat content was calculated using the formula;

$$\%\ \text{Fat content} = \frac{\text{Wt of flask} + \text{extract} - \text{tare Wt of flask}}{\text{Wt of sample}} \times 100$$

2.5 Crude fiber determination

The fat-free material obtained after the Soxhlet extraction of fat was used in the crude fiber determination. The fat-free material was transferred into a flask and 200 mL of pre-heated 1.25 % H_2SO_4 is added and the solution is gently boiled for about 30 minutes, maintaining constant volume of acid by the addition of hot water. The Buckner flask funnel fitted with Whatman filter is pre-heated by pouring hot water into the funnel. The mixture of the boiled acid sample is then filtered while hot through the funnel under sufficient suction. The residue is then washed several times with boiling water (until the residue is neutral to litmus paper) and transferred back into the beaker. Then 200 mL of pre-heated 1.25 % Na_2SO_4 is added and boiled for another 30 mins, filtered under suction and washed thoroughly with hot water and twice with ethanol. The residue is dried at 65 ºC for about 24 hours and weighed. The residue is transferred into a crucible and placed in a muffle furnace, model Gallenkamp size 2 (400 – 600 ºC) and ash for 4hrs, then cooled in a desiccator and weighed.

$$\%\ \text{Crude fibre} = \frac{\text{Dry wt of residue before ashing} - \text{wt of residue after ashing}}{\text{wt of sample}} \times 100$$

2.6 Crude protein

Crude protein content was determined according to Kjeldahl method (Method No. 978.04) [19], by measuring the nitrogen content of the samples and multiplying it by a factor of 6.25. 2 g each of the sample were weighed into Kjeldahl flask and digested with 25 mL of concentrated sulfuric acid, 0.5 g of copper sulphate, 5 g of sodium sulphate and a speck of selenium tablet, until clear pale green. Subsequently, 100 mL of distilled water was added rapidly to the digested sample when completely cool. Thereafter, 10 mL of the digested sample was measured into the Markham distillation apparatus and allowed to boil, 10 mL of sodium hydroxide was added to prevent the ammonia from being lost and distil into 50 mL of 2 % boric acid containing screened methyl red indicator. Alkaline ammonium borate formed is titrated directly with 0.1 *N* HCl. The titer value which is the volume of acid used is recorded. The volume of acid used is fitted into the formula;

$$\%\ \text{N} = \frac{14 \text{ x VA} \times 0.1 \times X\text{w} \times 100}{1000 \times 100}$$

VA = volume of acid used
w = weight of sample
% Crude protein = % N × 6

2.7 Nitrogen free extract (NFE)

Nitrogen free extract (NFE) represents soluble carbohydrates and other digestible and easily utilizable non-nitrogenous substances in the sample. Nitrogen free extract (NFE) was determined by mathematical calculation. It was obtained by subtracting the sum of all the other constituents that was obtained in the proximate analysis from 100 [20], using the formula:

% NFE = 100 - (% Moisture + % CF + % CP + % EE + % Ash)

NFE = nitrogen free extract that represents carbohydrate
CP = crude protein
CF = crude fiber
EE: ether extract or crude fat

2.8 Determination of energy

The energy contents of the samples were calculated using "Atwater factor:
"Energy (kcal/kg) = 3.5CP + 3.5 NFE + 8.5 CF where;

NFE = nitrogen free extract that represents carbohydrate
CP = crude protein
CF = crude fat

2.9 Statistical analysis

The experiments were carried out in triplicate. Average values of triplicate determinations were used for weight of whole sample versus the sample flesh and waste. Also, the mean of the proximate properties was compared using SPSS (Statistical Package for Social Scientist). And one way analysis of variance (ANOVA) was carried out to assess the significance differences in the data obtained. A p-value of 0.05 was accepted for statistical significance at the 95% confidence interval in all analysis.

3 Results and Discussion

The results of the proximate properties of the agricultural wastes and the discussion of the results are presented below;

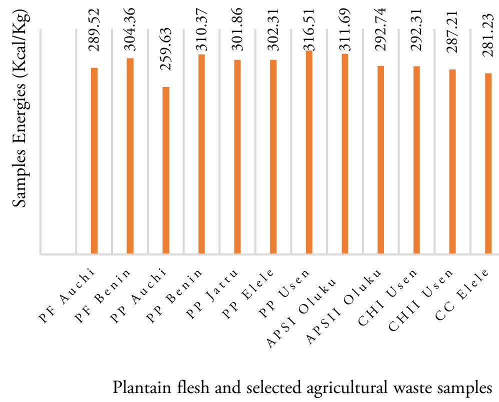

Figure 1. Energy (Kcal/kg) of samples

Table 1. Comparison between weight of whole sample versus the sample flesh and waste

S.NO	Sample code	Whole sample (g)	Sample flesh (g)	Sample flesh (%)	Sample waste (g)	Sample waste (%)
1.	Auchi Plantain	393.55	234.75	59.65	159.70	40.58
2.	Benin Plantain	267.15	154.03	57.66	113.12	42.34
3.	Jattu Plantain	357.30	221.50	61.99	135.50	37.92
4.	Elele Plantain	389.95	237.45	60.89	152.50	39.12
5.	Usen Plantain	258.73	147.93	57.18	110.83	42.84
6.	Oluku African pear (I)	127.10	73.40	57.75	53.90	42.21
7.	Oluku African pear (II)	113.60	64.10	56.43	49.50	43.57
8.	Usen Cocoa fruit (I)	718.40	160.90	22.40	557.40	77.59
9.	Usen Cocoa fruit (II)	612.30	181.35	29.62	430.90	70.37
10.	Elele Corn	189.45	120.95	63.84	68.50	36.16

Values are averages of triplicate determinations

Table 2. Moisture content, dry matter and ash content of plantain flesh and selected agricultural waste samples

S.NO	Sample code	MC %	DM %	Ash %
1.	PF Auchi	7.75 ± 0.01^{b}	92.25 ± 0.81^{d}	3.92 ± 0.95^{b}
2.	PF Benin	8.39 ± 0.32^{c}	91.60 ± 0.48^{c}	3.73 ± 0.65^{b}
3.	PP Auchi	7.15 ± 0.23^{b}	92.85 ± 0.07^{d}	6.17 ± 0.12^{c}
4.	PP Benin	8.24 ± 0.15^{c}	91.76 ± 0.85^{c}	6.31 ± 0.12^{c}
5.	PP Jattu	5.77 ± 0.78^{a}	94.23 ± 0.72^{e}	6.38 ± 0.15^{c}
6.	PP Elele	8.35 ± 0.60^{c}	91.65 ± 0.20^{c}	4.99 ± 1.04^{bc}
7.	PP Usen	6.34 ± 0.21^{ab}	93.56 ± 0.29^{de}	7.58 ± 0.65^{d}
8.	APSI Oluku	9.22 ± 0.07^{d}	90.77 ± 0.43^{b}	3.09 ± 0.80^{b}
9.	APSII Oluku	8.34 ± 0.01^{c}	91.66 ± 0.01^{c}	3.88 ± 0.60^{b}
10.	CHI Usen	7.58 ± 0.10^{b}	92.42 ± 0.30^{d}	5.34 ± 0.12^{bc}
11.	CHII Usen	8.32 ± 0.21^{c}	91.68 ± 0.32^{c}	4.31 ± 0.30^{bc}
12.	CC Elele	17.38 ± 0.25^{e}	82.62 ± 0.45^{a}	1.33 ± 0.13^{a}

Results are expressed as mean ± SD. Values on the same column with the same superscripts do not differ significantly at p<0.50.
PF Auchi = Flesh of plantain obtained from Auchi; **PF Benin** = Flesh of plantain obtained from Benin; **PP Auchi** = Peels of Plantain obtained from Auchi; **PP Benin** = Peels of Plantain obtained from Benin; **PP Jattu** = Peels of Plantain obtained from Jattu; **PP Elele** = Peels of Plantain obtained from Elele; **PP Usen** = Peels of Plantain obtained from Usen; **APSI Oluku** = Seed of African Pear obtained from Oluku; **APSII Oluku** = Seed of African Pear obtained from Oluku; **CHI Usen** = First Husk of cocoa pod obtained from Usen; **CHII Usen** = Second Husk of cocoa pod obtained from Usen; **CC Elele** = Cob of Corn obtained from Elele.

Table 3. Percentage fat, fiber crude protein, and nitrogen free extract of plantain flesh and selected agricultural waste samples

S.NO	Sample code	Fat %	Fiber %	Crude protein %	NFE %
1.	PF Auchi	5.13 ± 0.30^{c}	11.27 ± 0.34^{c}	7.00 ± 0.00^{a}	63.26 ± 0.90^{b}
2.	PF Benin	3.17 ± 0.16^{a}	5.44 ± 0.32^{a}	5.83 ± 1.03^{a}	73.43 ± 0.95^{d}
3.	PP Auchi	5.13 ± 0.89^{c}	6.34 ± 0.21^{a}	19.83 ± 0.79^{c}	55.38 ± 1.89^{ab}
4.	PP Benin	7.20 ± 0.19^{d}	7.22 ± 0.60^{b}	18.75 ± 0.90^{c}	52.44 ± 0.80^{a}
5.	PP Jattu	4.19 ± 0.60^{b}	5.97 ± 0.65^{a}	13.42 ± 1.01^{b}	62.65 ± 0.98^{b}
6.	PP Elele	5.35 ± 0.20^{c}	7.93 ± 0.87^{b}	13.42 ± 1.00^{b}	59.96 ± 0.95^{ab}
7.	PP Usen	6.33 ± 0.15^{cd}	4.20 ± 0.16^{a}	12.83 ± 1.09^{b}	62.23 ± 0.80^{b}
8.	APSI Oluku	6.24 ± 0.01^{cd}	7.54 ± 0.98^{b}	5.83 ± 1.09^{a}	68.07 ± 0.90^{c}
9.	APSII Oluku	4.27 ± 0.02^{b}	10.34 ± 0.21^{c}	11.08 ± 0.90^{b}	62.19 ± 1.09^{b}
10.	CHI Usen	5.36 ± 0.10^{c}	11.22 ± 0.01^{c}	18.67 ± 0.45^{c}	51.83 ± 0.80^{a}
11.	CHII Usen	5.18 ± 0.10^{c}	12.70 ± 0.40^{c}	16.33 ± 0.21^{c}	53.15 ± 0.32^{a}
12.	CC Elele	3.43 ± 0.32^{a}	8.80 ± 0.54^{b}	5.83 ± 0.98^{a}	63.22 ± 0.85^{b}

Results are expressed as mean ± SD. Values on the same column with the same superscripts do not differ significantly at p<0.50.
PF Auchi = Flesh of plantain obtained from Auchi; **PF Benin** = Flesh of plantain obtained from Benin; **PP Auchi** = Peels of Plantain obtained from Auchi; **PP Benin** = Peels of Plantain obtained from Benin; **PP Jattu** = Peels of Plantain obtained from Jattu; **PP Elele** = Peels of Plantain obtained from Elele; **PP Usen** = Peels of Plantain obtained from Usen; **APSI Oluku** = Seed of African Pear obtained from Oluku; **APSII Oluku** = Seed of African Pear obtained from Oluku; **CHI Usen** = First Husk of cocoa pod obtained from Usen; **CHII Usen** = Second Husk of cocoa pod obtained from Usen; **CC Elele** = Cob of Corn obtained from Elele

Comparison between weight of whole sample versus the sample flesh and waste is presented in Table 1. From this table, it can be observed that the percentages of the waste range from 36.16 to 77.59 %. Cocoa fruit had the lowest edible portion of 22.40 % and 29.26 %. This value is similar to the average 26 % reported by Kilama *et al.,* [21]. Lower values were reported by Soares and Oliveire for an edible portion of about 10% [22] in similar study with cocoa by-product. The percentage composition of plantain peels was found to vary from 37.92 – 42.84 % as compared to the flesh. The result also revealed that apart from the cocoa fruits which had the lowest edible portion, edible portions of other wastes were within 7.5 % apart.

The proximate properties of the selected agricultural waste presented in Tables 2 and 3 showed variations and values were statistically different at 0.05 % level. The analysis involved the determination of the major food component viz; moisture, ash, crude fat, crude protein, crude fiber, and carbohydrate.

The moisture content ranged from 5.77 to 17.38 % with dry matter content ranging from 82.62 % to 94.23 %. With the exception of CC (MC % = 17.38 %), the other samples had moisture content values comparable to values reported by Adeyi [23] where MC % values ranged from 5.43 ± 0.08 – 11.99 ± 0.09. The variation in the moisture content could be attributed to the difference in the variety of the waste, soil fertility, harvest time and geographical conditions. The high moisture content obtained for CC Elele is an indication that the waste will not be a suitable feedstock for thermo-chemical conversion [23, 24]. It also suggests that nutrient status of the waste will be lower compared to the other waste sample. Furthermore, high MC% values increase the rate of microbial growth that could also decrease the length of time it can stay fresh thereby leading to increased spoilage. Generally, Moisture content values of the wastes were lower than values obtained for plantain flesh with the exception of ASPI Oluku (9.22±0.07^{d}) as shown in Table 2. Also, PP Jattu (5.77 ± 0.78^{a}) had the lowest value, followed by PP Usen (6.34 ± 0.21^{ab}). Furthermore, moisture content values for PP Auchi (7.15 ± 0.23^{b}) and CHI Usen (7.58 ± 0.10^{b}) were statistically similar to PF Auchi (7.75 ± 0.01^{b}). However, these values were lower than values recorded for PF Benin (8.39 ± 0.32^{c}) which were statistically similar to PP Benin (8.24 ± 0.15^{c}), PP Elele (8.24 ± 0.60^{c}), ASPI Oluku (8.34 ± 0.01^{c}) and CHI Usen (8.32 ± 0.21^{c}). The low moisture content of the wastes suggest that microbial growth will be slow [25] thereby reducing spoilage time for the waste compared to the plantain flesh.

Ash content is the substance left after moisture and organic matter have been removed from a sample [26]. The ash content in this study ranged from 1.33 to 7.58 %. CC Elele has the lowest and PP Usen has the highest value. The ash content in all the plantain peels in this study were higher than the plantain flesh samples. The obtained ash content for plantain peels were between 4.99 to 7.58%. Ash content of PF Auchi (3.92 %), PF Benin (3.73 %), ASPI Oluku (3.09 %) and ASPII (3.88 %) were not statistically different and were considerably higher than the 1.30-3.0% obtained by Omohimi *et al.,* [27] for yam chips, flakes and flour. In this study, ash content of the wastes was generally higher than values recorded for the plantain peels. The high ash content of the wastes suggests that the samples are rich in minerals. Higher ash content in plantain peels as compared to plantain flesh indicates that plantain peel is richer in minerals, since ash represent the total mineral content in a sample [26]. Thus, the low ash content obtained for CC Elele in this study suggests that it is likely to have low mineral content.

The fat content ranging from 3.17 to 7.20 % were generally higher for the waste than the plantain flesh with the exception of CC Elele which was the waste with lowest fat content value and was not significantly different from PF Benin, while PP Benin had the highest value. Also, apart from PP Jattu and PP Auchi which had the same value as PF Auchi, fat content for all the plantain peels were higher than the plantain flesh. Furthermore, fat content values obtained in this study were within the range of 2.2 – 13.1 % reported for banana peels [28]. It is necessary that fats constitute about 1 – 2 % calorific energy value of food because it enhances food tastiness and flavor retention [29, 30]. The high fat content in waste compared to the plantain flesh suggests that the waste could be more palatable when used as food. Low fat content in diet requires supplementations of the food with energy concentrates. Nevertheless, excessive amount can lead to cardiovascular disorders such as atherosclerosis, cancer and aging [31, 32].

The fiber content reported in this study ranged from 4.20 to 12.70 %. PP Usen recorded the lowest value, which was not statistically different from PP Jattu, PP Auchi and PF Benin. The highest value was recorded by CHII Usen and was statistically similar to CHI Usen, ASPII Oluku and PF Auchi. The fiber content in all the waste samples were higher than the value recorded for PF Benin apart from PP Usen, while fiber content was lower than value recorded for PF Auchi in all the waste apart from CHII Usen. Also, values obtained in this study low compared to the 30.34 % (coconut husk), 33.60 % (cocoa pods) and 26.84 % (kola nut pod) obtained in a similar study [23]. Fiber in diet promotes bowel regularity, softens stool and increases its overall size and weight [33]. It also increases fullness, slows digestion and may help manage/lower cholesterol, which in turn keeps the heart functioning at its best [34]. Additionally, the poultry digestive systems require crude fiber to improve efficiency and contribute energy [35], given that poultry birds have high fat content [36].

The protein content in this study ranged from 5.83 to 19.83 %. CC Elele, ASPI Oluku and PF Benin recorded the lowest value (5.83 %) and were not statistically different from PF Auchi (7.00 %). PP Auchi had the highest value (19.83 %) and was statistically similar to PP Benin (18.73 %), CHI Usen (18.67 %) and CHII Usen (16.33 %). With the exception of CC Elele, ASPI Oluku and PF Benin which share the same value and are not statistically different from PF Auchi, protein content in all the agricultural waste samples in this study were higher than the plantain flesh samples. Protein content for plantain peels ranged between 11.08 to 13.42 % and were higher than values recorded for plantain flesh. These values were also high compared to the 3.62 to 7.75 % recorded for some agricultural waste [37]. Elsewhere, higher values (27.71%) have been recorded for kapok seeds [36] in a similar study. High protein content waste can be incorporated into animal feed to increase the protein content so as to enhance growth and replacement of lost tissues. It also serves as a sustainable and profit yielding waste management method.

Nitrogen free extract (NFE) represents the sugar and starch contents in a sample. All the waste samples had high NFE content ranging from 51.83 to 73.43 %. These values compared with the 58.54 % and 71.89 % values obtained for plantain flesh in similar studies [38]. Also, CHI Usen recorded the lowest NEF content (51.83 %) which was not statistically different from CHII Usen and PP Benin. Sugar and starch contents in this study were higher in plantain flesh samples, with PF Benin recording the highest NEF content (73.43 %) followed by PF Auchi (63.26 %). PF Auchi (63.26 %). The NEF values obtained in this study for African pear seeds (APSI = 68.07 % and APSII = 62.19 %) were considerably higher than the 39.10 % reported for African pear seed [24] in a similar study. High NFE content in samples is usually due to high carbohydrate content and could therefore serve as a potential source of carbohydrate and thus can be incorporated into livestock feed formulations to increase the carbohydrate content or it can be used as a substitute for grains and cereals.

The calorific energy content of the samples was similar, ranging from 259.63 Kcal/100 g (2596.3 Kcal/Kg) for PP Auchi to 316.51 Kcal/100 g (3165.1 Kcal/Kg) for PP Usen. These values were higher than the 2092.48 Kcal/kg for Rice husk and 2379.76 Kcal/kg for Sawdust obtained in a similar study but however comparable to 2923.36 Kcal.kg value for Corn cob [39]. High calorific energy content is an indication that the waste can serve as a good source of energy if used as livestock feed.

4 Conclusion

The results obtained from this study showed significant variations among the samples ($p < 0.05$) with respect to their proximate properties. Ash content were higher in all the waste samples than the plantain flesh. Some nutrients were also higher in some waste than the plantain flesh. Plantain peels had the closest proximate properties to plantain flesh. The study showed that agricultural waste contains appreciable amounts of edible potions with nutrients that compares favorably with plantain flesh. And so can be harnessed as cheap alternative food source for livestock feeds to reduce the stern food competition between livestock and man. Also, converting agricultural waste to livestock feed would serve as a win-win method that would make these agricultural wastes more useful and also cut down on the scarcity food.

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