IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 17, Issue 3 Ser. 1 (March. 2024), PP 27-35
www.iosrjournals.org

Can Fruit And Tuber Peels Used As Feed Satisfy The Nutrient Requirements Of Rabbits? Evidence From Backyard Rabbitries In Port Harcourt, Nigeria

Ingweye, Julius Naligwu, Okorie, Kelechi And Onukwru Aminah Uchechi
Department Of Animal Science, Faculty Of Agriculture, University Of Port Harcourt, Port Harcourt, Pmb 5323, Port Harcourt, Nigeria

Abstract

Background: *Tuber and fruit peels might be used as alternative and sole feeds for rabbits, but, published nutrient values for these fruit and tuber peels as reported in literature vary widely. Hence, the nutrient content in crop peels fed to rabbits in Port Harcourt, Nigeria were evaluated to know if fed sole to rabbit, they might meet the nutrient requirements of the rabbits.*

Materials and Methods: *The peels were collected from 25 rabbit farmers, coded as YPP, PLP and SPP, for yam, plantain and sweet potatoes, respectively and analyzed. SPSS software was used for data analysis. One-way ANOVA was used to compare means and significant means were separated using LSD.*

Results: *The DM, CP, EE, CF, Ash, NFE, OM and DE (MJ/kg) ranged from 88.01–86.95, 7.82–6.34, 1.84–1.54, 37.13–9.85, 4.87–2.59, 65.85–37.96, 83.1–85.38 and 13.64–4.92, respectively, while Na, Ca, K, P, and Mg ranged from 0.187–0.154, 0.192–0.164, 0.392–0.373, 0.259–0.225, 0.205–0.175, respectively. The peels contained Fe (42.45–41.85 %), Cu (4.49–4.26 %), Zn (54.23–53.26 %), Mn (3.35–3.27 %), Se (0.126–0.038 %), NDF (74.71–17.40), ADF (62.04–11.68), ADL (21.04–1.87), hemicellulose (18.80–5.72) and cellulose (41.01–9.81) in % DM. Trypsin inhibitors, tannins, phytates, oxalates, saponin and alkaloids ranged from 1.44–1.26 mg/g, 0.0021–0.0015 %, 0.748–0.482 %, 0.479–0.317 %, 0.567–0.532 % and 0.405–0.296 %.*

Conclusion: *Feeding peels sole to rabbits might satisfy their Mg, Fe, Cu, Zn, Mn and Se need. PLP might satisfy rabbit requirements for CF and ash, while YMP and SPP might satisfy rabbit need for NFE. YMP and PLP might satisfy rabbit requirements for fibers. Though antinutrients were below toxic levels, supplementing peels deficient in some nutrients might ensure rabbit optimal performance.*

Keywords: *By-products, agro-processing wastes, food waste*

Date of Submission: 04-03-2024 Date of Acceptance: 14-03-2024

I. Introduction

Food waste is a part of food losses at any link in the food supply chain, as edible food products proceed towards human consumption (Gustavsson *et al*., 2011). Globally, one-third of the food produced is wasted while, more than 40% of food losses, along the food value chain in developing countries, occur at post-harvest and processing stages (Gustavsson *et al*., 2011). For instance, sub-Saharan Africa produces 460 kg of food per year per capita of which 6–11kg per year per capita is wasted during the consumption phase of the chain (Gustavsson *et al*., 2011).

Root and tuber food crops dominate food supply in developing countries such as Nigeria, yielding about 836 million tonnes per annum (FAOSTAT, 2013). Domestic and industrial processing of those tubers and fruits into many products often generates peels which are of low economic value, hence, are usually discarded, thereby ending up as lost food (Torres-Leon *et al*., 2018). For instance, Nigeria generates 10.2, 10.5 and 0.9 million metric tons of yam, cassava and plantain peels per annum (Longjan and Dehouche, 2018). These peels make up 15–20% of the fresh weight of tubers, 31% of pawpaw, 40% of banana and plantain and as much as 50–70% of citrus (Gustavsson *et al*., 2011). Feeding those peels to animals could positively impact the environment. For example, banana peels can be fed to livestock in fresh or green, ripe or dry form (GAPL, 2015).

Beyond the high volume of peels produced, peels generated from fruits and tuber processsing are rich in nutrients that could be utilized by livestock to enhance their growth and production. For instance, processing of yams yield peels with 11.3–12.6 MJ/kg energy and 91.4–127 g/kg crude protein (Diarra, 2018). According to Abdel- Hafeez *et al*. (2018), sweet potato peels are high in energy (11.25 MJ/kg ME), average in crude protein (36–46 g/kg) and low in crude fibre (38–70 g/kg). Peels from coloured sweet potato varieties are rich in carotenoids, potentially minimizing the need for supplements that could put desirable pigments in eggs and skin of poultry (Diarra, 2018). Also, peels are rich in phenolic compounds (Wedzerai, 2019).

But anti-nutritional factors minimize the food value of fruits and tuber crops and are concentrated in the peels (Kwazo *et al*., 2021). Nevertheless, the importance of peels as animal feed is increasing. This newfound relevance stems from increased breeding of crops for low antinutrients, advances in processing technologies, increasing availability of feed grade enzymes and toxin binders, as well as better access to feed markets (FAOSTAT, 2013). The reduction of antinutritional factors in the peels and enhncement of peel nutritional value, has made peels more valuable to livestock such as ruminants and pseudo-ruminants (rabbits), which have been traditionally fed peels, as supplements to forages, in backyard animal husbandry systems, especially, in developing tropical countries like Nigeria.

Rabbits reared for food by smallholder farmers in Nigeria are one of the major consumers of agro-industrial by-products and household organic wastes, which are non-edible to humans. Majority of those wastes are peels from tubers such as cassava, yam and potatoes, as well as fruits.

Root, tuber and fruit crops have been used as replacement for maize, to supply livestock with dietary energy. However, the increasing cost of maize has also, by association, increased the cost of alternative energy sources such as tuber crops. This has compelled farmers to use by-products generated from those alternative energy sources, as feed for animals. The use of by-products from those alternatives to maize for animal feed becomes more compelling, if such by-products are inedible to man, of low economic value and an environmental headache to discard (Diarra, 2018). One way to effectively dispose of those by-products sustainably is to feed them to animals (van Zanten *et al*., 2019). However, peels are high in fiber, low in nutrients and contain anti-nutritional factors that could minimize their dietary value for poultry (Diarra, 2018). But, the peculiar gastro-intestinal tract of rabbits is endowed with the ability to convert huge quantities of high fiber, low nutrient and anti-nutrient-containing peels to rabbit feed at rate not possible in chickens. This ability, called refection, is due to the presence of the caecum at the distal part of large intestine that is rich in microorganisms (Carabano *et al*., 2020).

However, published nutrient values for these fruit and tuber peels as reported in literature vary widely (Diarra, 2018) between crop varieties, age at harvest, cultivation practices, processing methods, uses, climate, soil and region where they were grown. The variations influence the nutritive value of the peels, which possibly transferred to the animals consuming the peels. Also, the inclusion levels of the peels in diets as well as breed and age of animals could influence the utilization of those peels by rabbits (Diarra, 2018; Carabano *et al*., 2020). Hence, the objectives of this research were (i) to identify the types of fruit and tuber peels fed to rabbits by smallholder farms in Obio-Akpor and Ikwerre Local Government Areas of Rivers State, Nigeria (ii) to determine the nutrient contents in those fruit and tuber peels so identified (iii) to compare the nutrient contents so determined with the nutrient requirement of rabbits and see whether the nutrients required by rabbits might be satisfied, if the fruit and tuber peels were fed sole to rabbits, as commonly practiced by smallholder farmers in the study area.

II. Materials And Methods

Study area

The research was carried out in two Local Government Areas (Ikwerre and Obio-Akpor) of the twenty-three in Rivers State. These Local Governments were purposively sampled for the study because they had the highest number of rabbit farmers in Rivers State. The regional topography is composed of flat land of about 4820 km^2 situated at 20 meters above sea level (Dan-Jumbo *et al*., 2018). Also, the area is between latitude 4º42'N and 4º47'N and longitudes 6º55'E and 7º08'E (Ikechukwu, 2015). The population of the place in 2019 more than 2 million people (Demographia, 2019). The major occupations were mainly small-scale farming, fishing, civil service jobs and small-scale business. These occupations all depend directly or indirectly on the oil and gas industry which is the backbone of Rivers State economy (Dan-Jumbo *et al*., 2018).

Sampling and data collection

Mixed methods were used in this research:

(i) *Identification and collection of samples of fruit and tuber peels used as rabbit feed*

Multistage sampling method was used to select the interview subjects. First, out of the 23 Local Government Areas (LGAs) in Rivers State, two (Obio-Akpor: urban and Ikwerre: peri-urban) were purposively selected for the study. They were selected because from unpublished reports, they had the highest number of smallholder rabbit farmers. Next, 25 smallholder rabbit farmers (15 from Ikwerre and 10 from Obio-Akpor) were identified using the snowballing sampling method because the responsible Rivers State Government agency had no rabbit farmers' register. In the snowballing method, enquiries were made in the study area about rabbit farmers. The first farmer identified was interviewed. After the interview, the farmer was asked to direct the researcher to any other farmer they knew. From the next farmer, the linkage to other farmers was made and so on; escalating the linkage to more respondents. After identification, samples of all fruit and tuber peels used as rabbit feed in the 25 farms were collected, coded (yam, plantain and sweet potatoes peels were coded as YPP, PLP and SPP, respectively) and analyzed for proximate composition, minerals content, fiber fractions and anti-nutritional factors while digestible energy, organic matter and nitrogen free extractives were calculated using appropriate formulas.

(ii) Proximate composition, minerals, fiber fractions, and anti-nutritional factors analyses

The proximate components analyzed include dry matter, crude protein, ether extract, crude fiber, ash and nitrogen free extract. The samples were analyzed chemically in triplicates, according to the official methods of analysis as described by Association of Official Analytical Chemist (AOAC, 2005). Dry matter (DM) was determined by placing 2 grams of sample in an oven set at 100ºC for 24 hours and drying the sample to constant weight. Supposing the weight of the empty crucible was W_o, weight of crucible plus sample was W_1, weight of crucible plus oven-dried sample was W_3, percentage dry matter was: Percent DM = $W_3–W_o ÷ W_1–W_o$ x 100÷1. Crude protein (CP) was determined by routine semi-micro Kjeldahl procedure consisting of digestion, distillation and titration techniques. Percent crude protein was determined by multiplying percentage nitrogen content by a constant factor of 6.25 i.e. percent CP=%N x 6.25. Either extract (EE) was determined using Soxhlet apparatus method. Supposing initial weight of dry Soxhlet flask was W_O, final weight of oven-dried flask + oil was W_1, the percent EE = $W_1–W_o$ ÷ Weight of sample x 100÷1. Ash was determined by method 942.05 using 2grams of sample in a muffle furnace at 550ºC for 4 hours. Percent ash = Weight of ash ÷ Original weight of sample = 100÷1. Crude fiber (CF) content was determined with method 958.06 using 2grams of sample in fiber flask where W_1 = weight of oven dried crucible containing residue, W_2 = weight of cooled crucible containing white or grey ash (free of carbonaceous materials). Percent CF = $W_1–W_2$ ÷ Weight of sample x 100÷1. Nitrogen free extract (NFE) was calculated by difference through subtracting the sum of percent moisture, crude protein, ether extract, crude fiber and ash from 100, i.e. NFE = (%Moisture + %CP+%EE+%CF+%Ash). Digestible energy (DE) and organic matter (OM) were estimated using the formulae $DE=15.627+0.000982*CP^2+0.0040*EE^2–0.0114*Ash^2–0.169$ MJ/kg DM and OM = %DM–%Ash, respectively (Lebas, 2013).

Minerals analyses

Macro-minerals that were analyzed include sodium (Na), calcium (Ca), phosphorus (P), potassium (K), and magnesium (Mg), while the micro-minerals that were analyzed include zinc (Zn), iron (Fe), copper (Cu), manganese (Mn), and selenium (Se). Ca, K and Na were analyzed using Jenway Digital Flame Photometer (PFP7 Model) and Buck 200 Atomic Absorption Spectrophotometer as described by AOAC (2005). Concentration of elements was calculated using the formula: % Ca or % K or % N =Meter reading x slope x dilution factor, where meter reading x slope x dilution factor = Concentration in ppm or mg/kg. Concentration in percentage = Concentration in ppm ÷ 10,000. Phosphorus was determined by vanado-molybdate spectrophotometric method 975.16. Concentration of phosphorus expressed as percentage phosphorus was calculated: Percentage phosphorus = Absorbance x Slope x Dilution factor ÷10000. Selenium (Se), manganese (Mn), lead (Pb), cadmium (Cd), copper (Cu), iron (Fe), nickel (Ni), and zinc (Zn) were determined using digest of ash from calcium and phosphorus analysis, Buck 200 Atomic Absorption Spectrophotometer and method 975.23. Meter reading for each element was used to calculate concentration of each element using the formula: Element (ppm) = Meter reading x Slope x Dilution factor while Element (%) = ppm ÷ 10000.

Fiber fractions analyses

Fiber fractions that were analyzed and calculated include neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), hemicelluloses and cellulose according to Van Soest (1963). NDF was analyzed using 1gram of dried ground sample, Neutral Detergent Solution, decaline and sodium sulphate. Percent NDF was calculated using the formula: Percent NDF = (Weight of crucible + Dry NDF–Weight of empty crucible) x100÷Weight of sample. Percent soluble constituents=100–%NDF. ADF was determined using 1gram of dried sample, cold Sulphuric acid-CTAB solution and decaline. Percent ADF was calculated with the formula: Percent ADF = (Weight of crucible + dry ADF –Weight of empty crucible) x100÷Weight of sample. Percent Hemicellulose = %NDF–%ADF, while percent Cellulose was calculated as: % Cellulose = %ADF–%ADL. To determine ADL, ADF residue obtained was treated with 72% Sulphuric acid and calculated using the formula: Percent ADL=$W_1–W_2$ x100÷Weight of sample. Where W_1 = Weight of crucible plus acid free residue, W_2=residue ash weight plus weight of crucible. The method of Van Soest (1963) was applied in the analysis and calculation of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), hemicellulose and cellulose.

Anti-nutritional factors analysis

Phytate, tannin, saponin, oxalates, alkaloids and trypsin inhibitors were determined according to methods of Mohamed *et al*. (1986), Zia-Ul-Haq *et al*. (2007), Shukla and Thakur (1986), and Tuleun and Patrick (2007).

Tannin: Tannins were determined by adding 400mg of each sample into separate titration flasks. Then 40ml ether containing 1% ethanoic acid (v/v) was added and mixed thoroughly to eliminate the pigments. Each supernatant was carefully eliminated after 5 minutes. Then, 20ml of 70% aqueous acetone was added. The flasks were then closed with cotton plug and covered with aluminum foil, and put in electrical shaker for two hours for the extraction. The flasks contents were sifted through Whatman filter paper 42. The filtrates were used for analyses by measuring 50 ml of each into test tubes. The volume of each was increased to 1.0 ml with distilled water. Thereafter, 0.5ml of Folin Ciocalteu reagent was added to each and mixed appropriately. Then, 2.5ml of 20% $NaHCO_3$ solution was added and mixed. The mixtures were stored for forty minutes at room temperature. Thereafter, the absorbances were determined using spectrophotometer while concentration was determined from the tannic acid standard curve.

Phytates: Two grams for each sample were separately weighed into 250ml titration flask. Then, 100ml of 2% HCl was added to each sample in the flask for three hours. Next, they were sifted through two layers of hardened filter papers. Thereafter, 50ml of the filtrates were added to 250ml beaker. Then 100ml of distilled water was added to each of them to yield adequate pH. Next, 10ml of 0.3% NH_4SCN solution was put into each solution as indicator. The solutions were then titrated with standard $FeCl_3$ solution resulting in an endpoint colour that was a little brownish-yellow for five minutes. The percent phytic acid was then calculated.

Oxalates: One gram of each sample was put in a 250ml graduated flask. This was followed by addition of 190ml distilled water and 10ml of 6M HCl. They were mixed and warmed in a 90ºC water bath for 4 hours. After digestion, they were centrifuged at 2000 revolutions per minute for five minutes. The supernatants were thereafter diluted to 250ml. Three parts of 50ml each of the supernatants were vaporized to 25ml. The brown precipitate was sifted and washed while the combined solution and filtrates were titrated with concentrated NH_3 solution in droplets until the methyl orange colour transformed to light yellow. The solutions were warmed to 90ºC in a water bath. The oxalate was precipitated with 10ml of 5% $CaCl_2$ solution. The solutions were allowed to stand for 12 hours before being centrifuged. The precipitates were rinsed into a beaker with hot 25% H_2SO_4, made up to 125ml with distilled water, heated to 90ºC and titrated against 0.05M KMnO4.

Saponins: The saponin contents were analyzed using double extraction gravimetric method. Five grams (5g) of milled samples were combined with 50ml of 20% aqueous ethanol in a flask. This was warmed in water bath and periodically agitated for 1 hour 30 minutes at 55ºC temperature before being sifted using Whatman filter paper 42. The filtrates were removed using 50ml of 20% ethanol. All the extracts were then mixed. Next, the mixed extracts were evaporated to 40ml at 90ºC before transferring them to a filtering funnel where 40ml of ether was added and shaken strongly. Another extraction was repeatedly done using partitioning till the colour of the aqueous layer became clear. Next 60ml of normal butanol was used to extract the saponins. The mixed extracts were rinsed with 5% aqueous NaCl solution and dried by evaporation in a pre-weighed evaporation dish. Then it was oven-desiccated at 60ºC and reweighed after cooling in a dessicator. The procedure was redone twice to obtain a mean value. Saponin value was analyzed by difference and derived as a percentage of the original sample using the formula: Percent saponin = W1–W2÷Weight of sample x 100÷1; Where, W1 = Weight of evaporating dish, W2 = Weight of evaporating dish + sample.

Alkaloid: One hundred grams of the samples were milled and extracted with methanol for 24 hours using a Soxhlet apparatus. The extract was sifted while methanol was dehydrated on a rotary evaporator under vacuum at 45ºC to become dry. Some of the filtrate was dissolved in 2N Hydrochloric acid and then sifted. One ml of this solution was moved to a filtering funnel and rinsed three times with 10ml chloroform. The pH of this solution was changed to neutral with 0.1N Sodium Hydroxide. Next, 5ml of BCG solution and 5ml of phosphate buffer were mixed with the solution. The mixture was agitated to form a complex that was removed using 1, 2, 3, and 4ml chloroform by strong shaking. The extracts were gathered in a 10ml measuring flask and mixed to volume with chloroform. The absorbance of the complex in chloroform was measured at 470 nm.

Trypsin inhibitor analysis: The assay was done by adding 20µL of samples to 160µL OF 1.0 percent casein solution in 0.1M Tris-HCl buffer of 7.4 pH. The trypsin containing 20 µL of a 0.5 mg/ml solution was added. The mixture was warmed at 37ºC for 15 minutes before 0.4 mL 5% $C_2HCl_3O_2$ was included to stop the reaction. After centrifugation, the absorbance of the supernatant, which indicates the quantity of casein particles was determined at 280nm.

Data analysis

Statistical Package for Social Sciences (SPSS) version 24.0 (IBM Corp, 2018) was used to analyze the data. Descriptive statistics, one-way analysis of variance for comparison of means at 0.001% level of significance in SPSS were used while significant means were separated using Tukey test in the same software.

III. Results

Proximate composition of tuber and fruit peels

Table No 1 shows the proximate composition of tuber and fruit peels fed to rabbits in Port Harcourt, Rivers State. Results indicate significant differences ($p<0.001$) among treatment means for all parameters measured (DM, CP, EE, CF, Ash, NFE, OM and ME). YMP had the highest ($p<0.001$) DM (88.01 %), while SPP had the least value (86.95 %). The CP content ranged from 7.82–6.34 % with YMP having the highest (p<0.001) value, while PLP had the least. The highest (p<0.001) EE value (1.84 %) was observed for YMP, while SPP had the least (1.54 %). PLP had the most (p<0.001) CF value (37.13 %), while SPP had the least (9.85 %). Ash content ranged from 4.87–2.59 % with the highest (p<0.001) figure observed for PLP while lowest figure was recorded for SPP. Also, SPP had the highest (p<0.001) NFE value (65.85 %), while PLP had the least (37.96 %). Organic matter (OM) content for the peels ranged from 83.1 (PLP) to 85.38 (YMP) with the value for YMP being the highest (p<0.001) while that of PLP was the least. However, the OM value of PLP was not different (p>0.001) from that of SPP. Finally, SPP (13.64MJ/kg) had the highest digestible energy (DE) while that of PLP (4.92MJ/kg) was the least (p<0.001).

Table No 1: Shows proximate composition of tuber and fruit peels fed to rabbits in Port Harcourt

Components	Peels					
	YMP	PLP	SPP	*SEM*	*p-value*	*LOS*
DM (%)	88.21^{a}	87.97^{b}	86.95^{c}	0.19	0.000	***
Ash (%)	2.64^{b}	4.87^{a}	2.59^{c}	0.38	0.000	***
CP (%)	7.82^{a}	6.34^{c}	7.13^{b}	0.21	0.000	***
EE (%)	1.84^{a}	1.68^{b}	1.54^{c}	0.04	0.000	***
CF (%)	11.91^{b}	37.13^{a}	9.85^{c}	4.39	0.000	***
NFE (%)	64.01^{b}	37.96^{c}	65.85^{a}	4.50	0.000	***
OM (%)	85.38^{a}	83.1^{b}	84.36^{b}	0.34	0.000	***
DE (MJ/kg)	12.11^{b}	4.92^{c}	13.64^{a}	1.34	0.000	***

^{a,b,c} Means in the same row with different superscripts are significantly different (p<0.001);); SEM=Standard Error of Mean; DM=Dry Matter; CP=Crude Protein; EE=Ether Extract; CF=Crude Fiber; NFE=Nitrogen Free Extract; OM=Organic Matter; ME=Metabolizable Energy; YMP=Yam Peels; PP=Plantain Peels; SPP=Sweet Potato Peels; LOS=Level of Significance

Macro-minerals content in tuber and fruit peels

Macro-minerals content in peels in presented in Table No 2. Results indicate significant differences (p<0.001) among treatment means for all observed macro-minerals (sodium, calcium, potassium, phosphorus and magnesium). Percent sodium, calcium, potassium, phosphorus, and magnesium contents ranged from 0.187–0.154, 0.192–0.164, 0.392–0.373, 0.259–0.225, 0.205–0.175, respectively. PLP values for all macro-minerals were the highest (p<0.001), while YMP values were the least. However, the least values were not different (p>0.001) from those observed for SPP.

Table No 2: Shows macro-minerals content in tuber and fruit peels fed to rabbits in Port Harcourt

Minerals	Peels					
	YMP	PLP	SPP	*SEM*	*p-value*	*LOS*
Sodium (%)	0.154^{b}	0.187^{a}	0.159^{b}	0.005	0.000	***
Calcium (%)	0.164^{b}	0.192^{a}	0.169^{b}	0.004	0.000	***
Potassium (%)	0.373^{b}	0.392^{a}	0.378^{b}	0.003	0.000	***
Phosphorus (%)	0.225^{b}	0.259^{a}	0.228^{b}	0.005	0.000	***
Magnesium (%	0.175^{b}	0.205^{a}	0.178^{b}	0.005	0.000	***

^{a,b} Means in the same row with different superscripts are significantly different (p<0.001); SEM=Standard Error of Mean; LOS=Level of Significance; YMP=Yam Peel; PLP=Plantain Peel; SPP=Sweet Potato Peel

Micro-minerals content in tuber and fruit peels fed to rabbits

Table No 3 presents micro-minerals profile in fruit and tuber peels commonly fed to rabbits in Port Harcourt. It shows that among all micro-minerals assessed, there were significant differences (p<0.001) among treatment means. Percent iron and copper contents ranged from 42.45–41.85 and 4.49–4.26, respectively. SPP scored the highest (p<0.001) for iron and copper, while YMP had the least. PLP had the highest (p<0.001) content (54.23 %) for zinc, while SPP (53.26 %) had the least. However, the least zinc content was not different (p>0.001) from that observed for YMP (53.29 %). Manganese content observed for SPP (3.35 %) was the highest (p<0.001), while that of PLP (3.27 %) was the least. Nevertheless, the manganese content of YMP (3.31 %) was not different (p>0.001) from those observed for PLP and SPP. Selenium values ranged from 0.126–0.038 % with SPP being the highest (p<0.001), while YMP was the least.

Table No 3: Micro-minerals content in tuber and fruit peels fed to rabbits in Rivers State

Minerals	Peels					
	YMP	PLP	SPP	*SEM*	*p-value*	*LOS*
Iron (%)	41.85^{c}	42.38^{b}	42.45^{a}	0.09	0.000	***
Copper (%)	4.26^{c}	4.34^{b}	4.49^{a}	0.03	0.000	***
Zinc (%)	53.29^{b}	54.23^{a}	53.26^{b}	0.16	0.000	***
Manganese (%)	3.31^{ab}	3.27^{b}	3.35^{a}	0.01	0.000	***
Selenium (%)	0.038^{c}	0.044^{b}	0.126^{a}	0.014	0.000	***

[a,b,c] Means in the same row with different superscripts are significantly different (p<0.001); SEM=Standard Error of Mean; LOS=Level of Significance; YMP=Yam Peel; PLP=Plantain Peel; SPP=Sweet Potato Peel

Fiber fractions in tuber and fruit peels fed to rabbits

Table No 4 shows the profile of fiber fractions in tuber and fruit peels commonly fed to rabbits in Port Harcourt. Results indicate NDF, ADF, ADL, hemicellulose and cellulose values in percent dry matter ranged from 74.71–17.40, 62.04–11.68, 21.04–1.87, 18.80–5.72 and 41.01–9.81, respectively. PLP had the highest values (p<0.001) of NDF, ADF, ADL and cellulose, while SPP had the least. Also, YMP had the highest (p<0.001) hemicellulose value while SPP recorded the least.

Table No 4: Fiber fractions in tuber and fruit peels fed to rabbits in Port Harcourt

	Peels					
Fractions	YMP	PLP	SPP	*SEM*	*p-value*	*LOS*
NDF (% DM)	39.57^{b}	74.17^{a}	17.40^{c}	8.26	0.000	***
ADF (% DM)	20.77^{b}	62.04^{a}	11.68^{c}	7.75	0.000	***
ADL (% DM)	4.11^{b}	21.04^{a}	1.87^{c}	3.03	0.000	***
Hemicellulose (% DM)	18.80^{a}	12.12^{b}	5.72^{c}	1.89	0.000	***
Cellulose (% DM)	16.66^{b}	41.01^{a}	9.81^{c}	4.73	0.000	***

[a,b,c]Means in the same row with different superscripts are significantly different (p<0.001); SEM=Standard Error of Mean; NDF=Neutral Detergent Fiber; ADF=Acid Detergent Fiber; ADL=Acid Detergent Lignin; LOS=Level of significance; YMP=Yam Peel; PLP=Plantain Peel; SPP=Sweet Potato Peel; DM=Dry Matter

Anti-nutritional factors in tuber and fruit peels fed to rabbits

Anti-nutritional factors in tuber and fruit peels commonly fed to rabbits in Port Harcourt are presented in Table No 5. There were significant differences (p<0.001) among treatment means for all anti-nutritional factors examined. PLP had the highest (p<0.001) value (1.44 mg/g) of trypsin inhibitors, while YMP had the least (1.26 mg/g). However, the least value was not different (p>0.001) from that of SPP (1.31 mg/g). PLP scored the highest (p<0.001) value (0.0021 %) for tannins, while SPP (0.0015 %) scored the least. But, tannin content of YMP (0.0017 %) was not different (p>0.001) from those of PLP and SPP. Phytates and oxalates ranged from 0.748–0.482 % and 0.479–0.317 %, respectively. PLP recorded the highest (p<0.001) values for phytates and oxalates while SPP recorded the least. Nevertheless, the phytates and tannin contents of YMP (i.e. 0.486 % and 0.321 %, respectively) were not different (p>0.001) from those of SPP. PLP had the highest (p<0.001) saponin (0.567 %), while SPP value (0.532 %) was the least. Alkaloid values ranged from 0.405–0.296 % with YMP having the highest (p<0.001), while SPP had the least.

Table No 5: Anti-nutritional factors in tuber and fruit peels fed to rabbits in Port Harcourt

	Peels					
Anti-nutrients	YMP	PLP	SPP	*SEM*	*p-value*	*LOS*
Trypsin inhibitor (mg/g)	1.26^{b}	1.44^{a}	1.31^{b}	0.03	0.000	***
Tannin (%)	0.0017^{ab}	0.0021^{a}	0.0015^{b}	0.000	0.001	***
Phytate (%)	0.486^{b}	0.748^{a}	0.482^{b}	0.044	0.000	***
Oxalate (%)	0.321^{b}	0.479^{a}	0.317^{b}	0.027	0.000	***
Saponin (%)	0.554^{b}	0.567^{a}	0.532^{c}	0.005	0.000	***
Alkaloid (%)	0.405^{a}	0.387^{b}	0.296^{c}	0.017	0.000	***

[a,b,c] Means in the same row with different superscripts are significantly different (p<0.001); SEM=Standard Error of Mean; LOS=Level of Significance; YMP=Yam Peel; PLP=Plantain Peel; SPP=Sweet Potato Peel

IV. Discussion

Dry matter contents of the peels were within the ranges reported in several reports (Jiwuba and Okechukwu, 2018; Diarra, 2018; Ezieshi and Olomu, 2011). The values indicate that though YMP had higher (p<0.001) dry matter than others, all the peels could be stored for three months, without significantly deteriorating in quality (Esmail, 2017).

In this study, the crude protein (CP) of YMP was higher than in other peels, but lower than values reported in literature (Diarra, 2018; Ezieshi and Olomu, 2011), while those of SPP and PLP were higher than reported in literature (Diarra, 2018). The CP requirement for rabbits in a single feed under small and medium-scale rabbit units is 16 % (Lebas, 2013). The result implies that should any of these peels be fed sole to rabbits as is the norm in most rabbit farms in the study area, the animals may not meet their daily CP requirement by about 50 %, thus, requiring supplementation with other protein sources, if the animals must perform to their full potential.

The ether extract (EE) contents in all the peels were lower than reported in some literature (Popoola *et al*., 2021; Maloney *et al*., 2014), but higher than in others (Aruna *et al*., 2017; Ezieshi and Olomu, 2011). Differences could be attributed to the varieties of the yam, plantain and sweet potatoes, whose peels were used for the study (Diarra, 2018). In this study, samples were probably from mixed varieties of these fruit and tubers, because the farmers claimed so. Rabbits require 2–5.5 % dietary fats, depending on the class of rabbits, with pregnant and nursing does requiring from 3.0 % (MSUBT, 2017). The results imply that, should any of the peels be fed sole to rabbits, as is done by smallholder farmers in the study area, the rabbits not meet their EE requirement.

Compared to literature values, the CF content of YMP and SPP were within the reported range (Popoola *et al*., 2021; Ezieshi and Olomu, 2011; Diarra, 2018), whereas that of plantain peels was far above the reported values (Oyeyinka and Afolayan, 2019). Differences observed in the PLP could be due to the different varieties of the plantain used for this study and or the status of the peels at the time of analysis; whether ripe or unripe. In this study, mixed PLP (upripe and ripe) were used, which may have contributed to the higher CF content (Diarra, 2018). The CF requirement for rabbits is generally 15 % (Lebas, 2013), or 20 % for pregnant and nursing does and up to 27 % for dry does, herding bucks and growers (MSUBT, 2017). The consequence of the result is that should the peels be fed sole to rabbits, PLP may satisfy CF needs of rabbits without supplementation with other fiber sources, while YMP and SPP may not.

The ash content of PLP was low or high depending on the literature used for comparison (Oyeyinka and Afolayan, 2019; Shadrach *et al*., 2020). Differences might be due to varietal or stage of ripeness (Diarra, 2018). Ash content of YMP and SPP were low compared to literature values (Ezieshi and Olomu, 2011; Aruna *et al*., 2017; Solomon *et al*., 2015). Dietary ash requirement for all classes of rabbits range from 4–6.5% (MSUBT, 2017). Based on these results, it could be deduced that only PLP, when fed sole to rabbits, might satisfy their ash requirements.

The NFE contents of YMP, PLP and SPP were lower than values reported in literature (Solomon *et al*., 2015; Ezieshi and Olomu, 2011; Onojah and Emurotu, 2017). The NFE requirement for all classes of rabbits range from 43–50 % (MSUBT, 2017). This implies that, should they be fed sole to rabbits, YMP and SPP might satisfy the rabbit requirements, but, PLP might not, except supplemented with other NFE-rich feed ingredients.

The OM contents of the peels were within the ranges reported for YMP, PLP and SPP in literature (Diarra, 2018; Aruna *et al*., 2017; Abubakar *et al*., 2016), but below values suggested for standard rabbit diets (Alvarenga *et al*., 2017). This implies that the OM content needs to be upped for any of these peels to be confidently used as sole rabbit feed.

The DE need of most rabbits is 10MJ/kg (Lebas, 2013). In this study, YMP and SPP contents were higher than the rabbit requirements while PLP value was lower. This implies that PLP might not supply enough DE when fed sole to rabbits as energy source. Nevertheless, the three values were within the range reported in literature (Diarra, 2018; Aruna *et al*., 2017; Abubakar *et al*., 2016; Dako *et al*., 2016).

The calcium, potassium, and magnesium contents in YMP were within the range of values reported for YMP elsewhere, except phosphorus which was lower (Ezieshi and Olomu, 2011). Differences in phosphorus could be due to variety (Diarra, 2018). The sodium, calcium, potassium, phosphorus and magnesium contents of PLP in this study compared to literature values (Abubakar *et al*., 2016) were low. Differences could be due to whether the peels were ripe or unripe. In this study, the peels were a mixture of ripe and unripe. The sodium, calcium, potassium, phosphorus and magnesium contents of SPP compared to values reported in literature were low for sodium, calcium, magnesium and potassium were low (Salawu *et al*., 2015). Differences could be varietal (Sanoussi *et al*., 2016) and in this case, mixed varieties were used. PLP topped ($p<0.001$) in all the macrominerals assesed while jointly, YMP and SPP were the least. Generally, dietary sodium, calcium, potassium, total phosphorus, magnesium requirements by rabbits are 0.22, 1.10, 0.60–1.80 and 0.50 and 0.03–0.04 %, respectively (Lebas, 2013). Compared to those literature values, figures obtained in this study, for these minerals in all peels were low except magnesium values (TANUVAS, 2012). Those values may not satisfy rabbit dietary requirements, if these peels were fed sole to rabbits, except magnesium. These low values agree with Lebas (2013) that fruits and tuber by-products are low in those minerals.

SPP was the highest in iron, copper, manganese (also yam peel) and selenium while PLP was the highest in zinc while YMP had the least values. The iron, copper, zinc, and manganese requirements for rabbits are 0.005–0.01 %, 0.0005 %, 0.005–0.007 % and 0.00025–00085 %, respectively (TANUVAS, 2012). In this study, the observed values were high. It implies that should these materials be fed sole to any class of rabbits, they might satisfy their requirements for these micro-minerals.

PLP had the highest value for all fiber fractions except hemicellulose, while YMP had the highest hemicellulose. SPP recorded the least values for all fiber fractions assessed. Generally, NDF, ADF and ADL requirements for rabbits are 31 %, 17 % and 5%, respectively (Lebas, 2013). Based on these requirements, the NDF and ADF values of YMP and PLP were above the requirements for rabbits, while that of SPP was lower. This implies that feeding sole SPP to rabbits will require supplementation with other sources rich in NDF and ADF. The ADL content of PLP was above the requirement for rabbits while that of YMP was close, yet lower. The ADL content of SPP was low. Hence, feeding sole SPP to rabbits may need supplementation with sources rich in ADL. For best health of rabbits using single feed cellulose and hemicellulose of greater than or equal to 11 % and 10 % (converted from 110g/kg and 100g/kg, respectively), respectively is required (Lebas, 2004). In this study, the cellulose and hemicellulose of SPP were lower than required for rabbits, while those of YMP and PLP were sufficient. Hence, using SPP as a single feed for rabbits may not satisfy their celluolose and hemicellulose requirements.

Trypsin inhibitors can inhibit the proteolytic enzymes and are abundant in legume seeds as well as outer parts of their cotyledons (Lebas, 2004). Trypsin inhibitor in soybean interferes with availability of methionine in the raw beans. However, they are heat labile, but overheating destroys the amino acids and vitamins (Makkar, 1993). The trypsin inhibitor contents in the peels was low compared to literature and toxic thresholds (Kumar *et al*., 2017; Diarra, 2018; Lebas, 2004), hence, might unlikely cause harm to the rabbits consuming the peels.

Tannins have the capacity to form stable complexes with food proteins, hence, minimizing protein digestibility (Lewis, 2003). In this research, the tannin contents were comparable to values in peels reported in literature (Makkar, 1993). Inclusion of chestnut tannins up to 2.5g/kg had no deleterious effect on rabbits (Gai *et al*., 2010). Compared to this value, the tannin contents were low, hence, would unlikely have dangerous prospects for rabbits consuming any of the peels.

Phytate is the primary form of phosphorus in feeds and is easily digested by ruminants but difficult to handle by monogastrics (Marounek *et al*., 2003). The gastro-intestinal tract of rabbits, especially the caecum, is effective in completely hydrolizing dietary phytate (Marounek *et al*., 2003). The phytic acid in the yam, sweet potatoes and plantain peels were similar to figures reported for those peels in literature (Diarra, 2018; Marounek *et al*., 2003). Since phytic acid is only high in cereal seeds, legumes, oilseeds and nuts plus the fact that the caecum of rabbits is effective in complete hydrolysis of phytate (Marounek *et al.*, 2003), the potential of the low phytic acid levels constituting a hindrance to normal nutrition in the rabbit is low.

Oxalic acid binds with minerals like calcium, rendering them unusable to the body, while causing nutritional deficiencies and severe irritation to the gut. Oxalate content is higher in young than matured plants and leaves than other plant parts (Kumar *et al*., 2017). The oxalate content of the three peels were similar to those reported for peels in literature (Salem *et al*., 2011). About 20-30 mg percent of oxalate could negatively affect animals. Compared to this value, the values in this study were low, hence, might not pose a challenge when the peels are fed to rabbits.

Saponins are plant glycosides which can improve permeability of intestinal mucosa in vitro, inhibit active mucosal transport and facilitate uptake of normally unabsorbable substances (Francis *et al*., 2002). Excessive saponins in feeds may cause hemolysis of red blood cells, bloating in ruminants and inhibition of enzyme activity (Cheeke, 1971). Compared to deleterious thresholds in literature, the saponin values obtained for the three peels in this study were low (Cheeke, 1971; Awe and Sodipo, 2001; Salem *et al*., 2011) and would not likely be harmful to the animals when consumed.

Alkaloids are basic substances that contain nitrogen in heterocyclic ring and present in 15-20% of all vascular plants. Alkaloid values obtained in this research were comparable to those reported for the peels in literature (Hou *et al*., 2018). They were also lower than levels that could be detrimental to the health and nutrition of rabbits (Hou *et al.*, 2018; Lebas, 2004).

In all, PLP contained the most trypsin inhibitors, tannin, phytate, oxalate and saponin while yam peels contained the most alkaloid. All the antinutrient values were lower than those reported for YMP, PLP and SPP in literature (Dako *et al*., 2016; Oyeyinka and Afolayan, 2019; Adepoju *et al*., 2017). The low values could be due to the drying of the peels which is one of the methods used to detoxify feedstuffs (Diarra, 2018). Hence, the peels would unlikely have any deleterios effects on rabbits if the peels were fed to them sole.

V. Conclusion

The study assessed the chemical composition of fruit and tuber peels fed to rabbits by smallholder farmers in some LGAs of Rivers State to know whether if fed sole they might meet the nutrient requirements of rabbits. Feeding YMP, PLP and SPP sole to rabbits might satisfy their daily needs for magnesium, iron, copper, zinc, manganese and selenium but not CP, OM, EE, sodium, calcium, phosphorus and potassium. Also, plantain peels might satisfy rabbit requirements for CF and ash, but not NFE, while YMP and SPP might satisfy rabbit need for NFE but not CF and ash. More so, YMP and PLP might satisfy the rabbit requirements for NDF, ADF, ADL cellulose and hemicellulose while SPP may not. PLP contained the most trypsin inhibitors, tannin, phytate, oxalate and saponin while YMP contained the most alkaloid. Nevertheless, all antinutrients were low and unlikely to negatively affect rabbits consuming them. Finally, peels deficient in any nutrient, might need supplementation with other sources rich in the nutrient, to ensure the rabbits perform to their full potential.

References

[1]. Abubakar, U. S., Yusuf, K. M., Safiyanu, I., Abdullahi, S., Saidu, S. R., Abdu, G. T., Indee, A. M. (2016). Proximate And Mineral Composition Of Corn Cob, Banana And Plantain Peels. International Journal Of Food Science And Nutrition, 1(6): 25–27.

[2]. Adepoju, O. T., Boyejo, O. And Adeniji, P. O. (2017). Nutrient And Anti-Nutrient Composition Of Yellow Yam (Dioscorea Cayenensis) Products. Data In Brief, 11: 428–431.

[3]. Akinola, O. (2020). Nutritional Composition And Physio-Chemical Properties Of Peeled And Unpeeled Yam Flour (White Yam, Dioscorea Rotundata). Current Developments In Nutrition, 4(2): 735.

[4]. Alvarenga, I. C., Aldrich, C. G. And Kohles, M. (2017). The Effect Of Feed Form On Diet Digestibility And Cecal Parameters In Rabbits. Animals, 7 (95): 1–12.

[5]. Aruna, T. E., Aworh, O. C., Raji, A. O. And Olagunju, A. I. (2017). Protein Enrichment Of Yam Peels By Fermentation With Saccharomyces Cerevisiae (By4743). Annals Of Agricultural Science, 62: 33–37.

[6]. Awe, I. S. And Sodipo, O. A. (2001). Purification Of Saponins Of Root Of Blighiasapida. Nigerian Journal Of Biochemistry And Molecular Biology, 16 (3): 201-204.

[7]. Carabano, R., Piquer, J., Menoyo, D. And Badiola, I. (2020). The Digestive System Of The Rabbit. In: C. De Blas And J. Wiseman, Eds. Nutrition Of The Rabbit. Oxfordshire, Uk: Cab International, Pp. 1-20.

[8]. Cheeke, P. R. (1971). Nutritional And Physiological Implications Of Saponins: A Review. Canadian Journal Of Animal Science, 51: 621-632.

[9]. Dako, E., Retta, N. And Desse, G. (2016). Comparison Of Three Sweet Potatoes (Ipomoea Batatas (L.) Lam). Global Journal Of Science Frontier Research, 16 (4).

[10]. Diarra, S. S. (2018). Peel Meals As Feed Ingredients In Poultry Diets: Chemical Composition, Dietary Recommendations And Prospects. Journal Of Animal Physiology And Nutrition, 102: 1284–1295.

[11]. Esmail, S. H. (2017). Moulds In Feed: Know How To Prevent Them. All About Feed. Available Online At: Https://Www.Allaboutfeed.Net/Animal-Feed/Raw-Materials/Moulds-In-Feed-Know-How-To-Prevent-Them/. [Accessed 17 September 2021].

[12]. Ezieshi, B. V. And Olomu, J. M. (2011). Bio-Chemical Evaluation Of Yam Peel Meal For Broiler Chickens. Journal Of Agriculture And Social Research, 11(1): 36-48.

[13]. Faostat (2013). Fao Agriculture Statistics Database. Food And Agriculture Organization Of The United Nations, Rome, Italy. Available Online At: Http://Www.Apps.Fao.Org/Cgi-Bin/Nph_Db.Pl [Accessed 20 March 2021].

[14]. Francis, G., Kerem, Z., Makkar, H. P. S. And Becker, K. (2002). The Biological Action Of Saponins In Animal Systems: A Review. British Journal Of Nutrition, 88: 587–605.

[15]. Gai, F., Gasco, L., Schiavone, A. And Zoccarato, I. (2010). Nutritional Effects Of Chestnut Tannins In Poultry And Rabbit. In: G. K. Petridis, (Ed) Tannins: Types, Foods Containing And Nutrition: Nova Science Publishers Incorporated, Pp. 1–10.

[16]. Gapl (2015). Fruit And Vegetable Wastes As Livestock Feed. Growel Agrovet Private Limited (Gapl). Available Online At: Https://Www.Growelagrovet.Com/Livestock-Feed/ [Accessed 25 September, 2021].

[17]. Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., Meybeck, A. (2011). Extent Of Food Losses And Waste. In: Global Food Losses And Food Waste: Extent, Causes And Prevention. Rome: Food And Agriculture Organization, Pp. 4–9. Http://Www.Fao.Org/3/Mb060e/Mb060e02.Pdf.

[18]. Hou, Q. R., Zhao, W. G., Chen, T. And Li, L. (2018). Phytochemicals (Phenolic Acids, Flavonoids And Alkaloids) Contribution To The Feeding Value Of Mulberry (Morus Spp) For Rabbits. African Journal Of Agricultural Research, 13 (51): 2881-2888.

[19]. Jiwuba, P. C. And Okechukwu, O. S. (2018). Effects Of Cassava And Yam Peel Meals On Carcass Traits And Economics Of Production Of Finishing Broilers. Advances In Nutrition And Food Science, 2018 (01): 1-.

[20]. Kumar, B., Tirkey, N. And Kumar, S. (2017). Anti-Nutrient In Fodders: A Review. Chemical Science Review And Letters, 6 (24): 2513-2519.

[21]. Kwazo, H. A., Sulaiman, A. U., Abdulmumin, U., Muhammad, M. U., Mohammed, S. (2021). Comparative Assessment Of Chemical Composition And Anti-Nutrient Components Of Solenostemon Rotundifolius Tuber Pulp And Peel. African Journal Of Food Science And Technology, 12 (4): 01-06.

[22]. Lebas, F. (2004). Reflections On Rabbit Nutrition With A Special Emphasis On Feed Ingredients Utilization. Proceedings Of The 8th World Rabbit Congress., September 7-10, 2004, Pueblo, Mexico 2005 Pp.686-736. Corronsac, France, World Rabbit Science Association.

[23]. Lebas, F. (2013). Feeding Strategy For Small And Medium Scale Rabbit Units. Bali, Indonesia, 2nd International Conference On Rabbit Production In Indonesia And 3rd Conference Of Asian Rabbit Production Association Held August 27-29, 2013.

[24]. Lewis, W. H. (2003). Medical Botany: Plants Affecting Human Health. 2nd Ed. Hoboken. 459-485 Pp: John Wiley And Sons.

[25]. Longjan, G. G. And Dehouche, Z. (2018). Nutrient Characterization And Bioenergy Potential Of Common Nigerian Food Wastes. Waste Management & Research, 36 (5): 426–435.

[26]. Makkar, H. P. S. (1993). Antinutritional Factors In Foods For Livestock. In: M. Gill, E. Owen, G. E. Pollott And T. L. J. Lawrence (Eds). Animal Production In Developing Countries. Occasional Publication No 16. London: British Society Of Animal Production, Pp. 69-85.

[27]. Maloney, K. P., Truong, V. -D. And Allen, J. C. (2014). Susceptibility Of Sweet Potato (Ipomoea Batatas) Peel Proteins To Digestive Enzymes. Food Science And Nutrition, 2 (4): 351–360.

[28]. Marounek, M., Duskova, D. And Skrivanova, V. (2003). Hydrolysis Of Phytic Acid And Its Availability In Rabbits. British Journal Of Nutrition, 89: 287–294.

[29]. Msubt (2017). 4-H Rabbit Tracks: Feeds And Feeding. Michigan State University Board Of Trustees, Lansing, Michigan: Michigan State University Board Of Trustees.

[30]. Omole, A. J., Okpeze, C. N., Fayenuwo, J. A. And Olorungbohunmi, T. O. (2013). Effects Of Partial Replacement Of Maize With Yam Peel (Discorea Rotundata) In Diet Of Juvenile Snails (Archachatina Marginata). African Journal Of Agricultural Research, 8 (16): 1361-1364.

[31]. Onojah, P. K. And Emurotu, J. E. (2017). Phytochemical Screening, Proximate Analysis And Mineral Composition Of Ripe And Unripe Musa Species Grown In Anyigba And Its Environs. International Journal Of Research In Agricultural Sciences, 4 (3): 2348–3997.

[32]. Oyeyinka, B. O. And Afolayan, A. J. (2019). Comparative Evaluation Of The Nutritive, Mineral, And Anti-Nutritive Composition Of Musa Sinensis L. (Banana) And Musa Paradisiaca L. (Plantain) Fruit Compartments. Plants, 8: 598.

[33]. Popoola, Y. A., Kehinde, A. S., Oladele-Bukola, M. O., Banjoko, O. J., Durotoye, E. S., Omole, A. J. (2021). Nutritional Potential Of Pam Peel (Discorea Rotundata) As Feed Resource For Growing Snails (Archachatina Marginata). Journal Of American Science, 17 (1): 1-5.

[34]. Salawu, S. O., Udi, E., Akindahunsi, A. A., Boligon, A. A., Athayde, M. L. (2015). Antioxidant Potential, Phenolic Profile And Nutrient Composition Of Flesh And Peels From Nigerian White And Purple Skinned Sweet Potato (Ipomea Batatas L.). Asian Journal Of Plant Science And Research, 5 (5): 14–23.

[35]. Salem, A. Z. M., Cardoso, D., Camacho, L. M., Montanez, O. D., Cruz, B., Olivares, J. (2011). Plants-Rich Phytochemicals In Rabbit Feeding. In: A. Z. M. Salem (Ed.). Plant Phytochemicals In Animal Nutrition: Nova Science Publishers Inc., Pp. 1–18.