RESEARCH ARTICLE

Nutritional evaluation of the peels from *Citrullus lanatus* and *Manihot esculenta*, an insight into the conversion of waste to food

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ABSTRACT

Background: Huge quantity of cassava and watermelon wastes are daily discharged to the environment with unwholesome consequences. Therefore, research into the effective utilization of these agricultural by-products is of global interest.

Methods: The present study evaluated the proximate, minerals, and amino acid compositions of cassava and watermelon peels using standard procedures.

Results: The results revealed that carbohydrate is the most abundant proximate contents of both the cassava (82.14±0.42%) and watermelon (62.58±0.78%) peel, followed by crude fiber (5.51±0.06% and 18.90±0.04%), moisture (8.31±0.04% and 5.20±0.07%), crude ash (1.25±0.03% and 7.25±0.04%) for cassava and watermelon peels respectively, while crude fat (0.98±0.03% and 3.92±0.06%) is the least abundant proximate in both samples. Magnesium is the most abundant mineral contents of both the cassava (79.50±4.45Mg/100g) and watermelon (75.53±3.70Mg/100g) peel, followed by sodium (62.35±0.79 Mg/100g and 52.24±3.24 Mg/100g), potassium (22.12±1.34 and 32.65±2.01 mg/100g) for cassava and watermelon peels respectively while copper (0.73±0.05 Mg/100g and 0.67±0.64 Mg/100g) was the least abundant minerals in both samples. The total amino acid compositions of 66.31±4.56 g/100g and 41.80±2.68 g/100g were recorded for cassava and watermelon peel. Glutamic acid (9.96±0.06g/100g) and leucine (4.03±0.05 mg/100g) the most abundant amino acid in cassava and watermelon seed respectively.

Conclusion: In conclusion, the peels of cassava and water melon examined, have appreciable levels of nutrients compositions that can be incorporated into human and animal feed formulation.

Keywords: Proximate; minerals; amino acid; cassava peels; water-melon peels

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1.0 Introduction

One of the most common problems in food processing is the disposal of the waste material generated. This "waste material" produces ecological problems related to the proliferation of insects and rodents and an economical burden because of transportation to repositories, therefore strategies for the profitable use of these materials are needed (Hussein *et al.*, 2011). In the food processing industry, edible portions of fruits are processed into products such as puree, canned slices, juice, and pickles, whereas peels often will be

discarded as waste since it is not currently utilized for commercial purposes (Ajila *et al.*, 2007). Peels are also a promising source of useful compounds because of their favorable technological or nutritional properties (Schieber *et al.*, 2001).

Watermelon [*Citrullus lanatus* (Thunb.)], belonging to the *Cucurbitaceae* family is widespread in tropical and subtropical regions of the world (Achu *et al.*, 2005). Watermelon is primarily consumed as a fruit because of its sweet flavor and high nutritional value. It has been widely used in several regions of the world, especially in Africa and

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Asia, not only as a source of nutrition but also as a folk remedy for the treatment of diseases (Artwatermelon, 2007; Ziyada and Elhussien, 2008). Watermelon peel is recently gaining importance due to its nutritional and medicinal value. It has high nutritional value and is utilized for human consumption as snacks after salting and roasting in Arabian and Asian regions (Ziyada and Elhussien, 2008).

Cassava (*Manihot esculenta* Cranz) is a dicotyledonous plant, belonging to the family Euphorbiaceae (Alves, 2002). It is a perennial shrub, 2 to 4 m in height, and is mainly propagated from stem cuttings. Cassava forms a staple food for an estimated 500 million people in the tropics. It is widely grown in most countries in the tropical regions of Africa, Latin America, and Asia. The crop is an important source of carbohydrate for humans and animals, having higher energy than other root crops, 610 kJ/100 g fresh weight. Dried cassava root has energy similar to the cereals (FAO, 1990). In Africa, the continent with the largest cassava production, about 93% of the produce is used as food (Nweke *et al.*, 2002). Cassava can be transformed into various products such as 'gari', 'fufu', 'lafun' and many other West African traditional dishes (Afoakwa *et al.*, 2010).

Cassava processing factories are tremendous and the impacts on the environment could be annihilated thus giving rise to the need for proper management and release of these wastes. More of the waste product from cassava processing come from mainly Garri and starch processing factories and will only be useful if the peels can be incorporated into the livestock diet formulation. The use of cassava peels in livestock feeding would help to solve the trouble of its disposal as a waste product and likewise to bring down the monetary value of livestock production (Somendrika *et al.*, 2017). It is, therefore, necessary to investigate the nutritional composition of watermelon and cassava peel in order to elucidate their chemical and nutritional composition, optimize their utilization and ascertain their usefulness to the economy, health, and nutritional benefits.

2. Material and methods

2.1 Sample Collection and preparation

The cassava and watermelon peels (Figure 1) were obtained from Bosso market in Minna, Niger state,

Nigeria in March 2018. The peels were washed, allowed to drain and placed on a foil paper. The seeds were air dried for 2 weeks. The dried samples were pulverized using electronic blending machine and stored in plastic container prior to the analysis

2.2 Reagents and Chemicals

All chemicals used were of analytical grade and were products of Sigma Chemical Co., USA. They include Mayer's Reagent, Wagner's Reagent phosphate buffer, chloroform, HCl, NaOH, 3,5-dinitrosalic acid, FeCl₃, Conc ammonium hydroxide, hexane, Conc H₂SO₄.

2.3 Proximate Analysis

The proximate (crude proteins, crude fiber, moisture content, ash content, crude fat and carbohydrate) analysis of the sample was carried out by the methods of AOAC, (1990) as reported by Onwuka, (2005). The moisture content of was determine by oven drying two grams (2g) of the sample in an oven (Gallenkamp, UK) at 105°C for 24 hrs. The dried sample was then cooled in a desiccator for 30 minutes and weighed.

The ash content was determined by the incineration of five grams (5 g) of the sample in a muffle furnace at 550°C for 2hrs. Crude lipid (CL) was Soxhlet extracted from three grams (3 g) of the sample with petroleum ether for 10 hrs. Crude fibre (CF) content was determined by treating 1 g of defatted sample with 1.25% (w/v) H₂SO₄ and 1.25% (w/v) NaOH. The nitrogen (N) content was estimated by micro-Kjeldahl method and crude protein (CP) content calculated as N% x 6.25. The available carbohydrate (CHO) was calculated using the formula: % carbohydrate = 100- (M+P+F+A+F₂+L).

Where

M = % Moisture, P = % Protein, F₁ = % Fat, A = % Ash F₂ = % Crude Fiber L = % Crude Lipid

2.4 Determination of Amino Acid Profile

The Amino acid compositions of the samples were determined using methods described by Benitez (1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer. The sample was defatted using chloroform/methanol mixture of ratio 2:1. About 500mg of the sample was put in extraction

thimble and extracted for 15 hours in soxhlet extraction apparatus (AOAC, 1990).

The defatted sample was weighed into glass ampoule. 7ml of 6NHCL was added and oxygen was expelled by passing nitrogen into the ampoule (this is to avoid possible oxidation of some amino acids during hydrolysis e.g methionine and cystine). The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at $105^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. It should be noted that tryptophan is destroyed by 6N HCL during hydrolysis. The filtrate was then evaporated to dryness using rotary evaporator (AOAC, 2006).

The residue was dissolved with 5ml to acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer. A 60 microlitre of the sample was dispensed into the cartridge of the analyzer. The analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydrolysate. An integrator attached to the Analyzer calculates the peak area proportional to the concentration of each of the amino acids (Benitez, 1989).

2.5 Mineral analysis

The concentration of sodium, potassium, calcium, magnesium, copper, manganese, iron, zinc and phosphorus in the cassava peel and water melon seed were analysed according to AOAC (1990). Ten grams (10g) of each of the samples was heated over flame and ashed in muffle furnace at 450°C for 8 hours. Ten (10 mL) of diluted HCL was added to the ash and boiled for 5 minutes. The boiled ash was made up to 100 ml with distilled water. Analysis was performed in triplicate using atomic absorption spectrophotometer according to the standard methods of AOAC (2000).

2.6 Statistical analysis

Data collected were subjected to statistical analysis using the statistical package for social science version 21.0 and express as mean $\pm$ standard error of mean (SEM). Statistical significance of the results between groups was determined using One-way analysis of variance (ANOVA) followed by Duncans multiple range test (DMRT) Differences in mean were considered to be significant at $p < 0.05$ (Adamu and Johnson, 1997).

A

B

Figure 1: Waste product use in this study (A) water melon peel (B) cassava peel collected from Bosso market in Minna, Niger state, Nigeria

3.0 Results

3.1 Proximate Compositions

The proximate compositions of cassava peel and water melon seed are shown in Table 1: The results revealed that carbohydrate is the most abundant proximate contents of both the cassava ($82.14 \pm 0.42\%$) and water melon ($62.58 \pm 0.78\%$) peel, followed by crude fibre ($5.51 \pm 0.06\%$ and

$18.90 \pm 0.04\%$), moisture ($8.31 \pm 0.04\%$ and $5.20 \pm 0.07\%$) crude ash ($1.25 \pm 0.03\%$ and $7.25 \pm 0.04\%$) for both cassava and water melon peels respectively while crude fat ($0.98 \pm 0.03\%$ and $3.92 \pm 0.06\%$) was the least abundant proximate in the both samples. Water melon peel contains higher ash, proteins, fat and crude fiber contents than the cassava peel while cassava peel contains higher proteins, fat and carbohydrate contents

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Table 1: Proximate compositions of cassava peel and water melon peel

	Cassava Peel (%)	Water melon Peel (%)
Moisture	8.31±0.04 ^b	5.20±0.07 ^b
Ash	1.25±0.03 ^{ab}	7.25±0.04 ^c
Protein	1.81±0.08 ^b	2.15±0.07 ^a
Crude fibre	5.51±0.06 ^c	18.90±0.04 ^d
Fat	0.98±0.03 ^a	3.92±0.06 ^{ab}
Carbohydrate	82.14±0.42 ^d	62.58±0.78 ^e

Data are Mean ± SEM of triplicate determination. Value with different superscript alphabet are significantly different (p <0.05)

3.2 Minerals Compositions

The minerals compositions of cassava and water melon peel are shown in Table 2: Results revealed that magnesium is the most abundant minerals contents of both the cassava (79.50±4.45Mg/100g) and water melon (75.53±3.70Mg/100g) peel, followed by sodium (62.35±0.79 Mg/100g and 52.24±3.24 Mg/100g), potassium (22.12±1.34 and 32.65±2.01 mg/100g) for both cassava and water melon peels respectively while copper (0.73±0.05 Mg/100g and 0.67±0.64 Mg/100g) is the least abundant mineral in the both samples. Water melon peels contain higher copper, manganese, zinc, calcium and potassium while other minerals were higher in cassava peel

Table 2: Mineral compositions of water melon and cassava peels

Minerals	Cassava Peel (Mg/100g)	Water melon Peel (Mg/100g)
Copper	0.73±0.05 ^a	0.67±0.64 ^a
Iron	29.09±1.04 ^d	14.19±0.29 ^c
Manganese	1.69±0.02 ^b	3.72±0.95 ^b
Zinc	12.90±0.90 ^c	23.10±0.37 ^d
Calcium	24.13±0.46 ^d	30.45±0.75 ^e
Magnesium	79.50±4.45 ^f	75.53±3.70 ^g
Sodium	62.35±0.79 ^e	52.24±3.24 ^f
Potassium	22.12±1.34 ^d	32.65±2.01 ^e
phosphorus	20.18±0.57 ^d	18.75±0.65 ^c

Data are Mean ± SEM of triplicate determination. Value with different superscript alphabet are significantly different (p <0.05)

3.3 Amino acid compositions

The amino acid compositions of cassava and water melon peels are shown in Table 3: Results revealed that the total amino acid of 66.31±4.56 g/100g and 41.80±2.68 g/100g was recorded for cassava and water melon peels respectively. Glutamic acid 9.96±0.06g/100g was the most abundant amino acid in cassava peel followed by aspartic acid (6.70±0.03 g/100g) and alanine (5.84±0.07 g/100g), however, in water melon peel, leucine (4.03±0.05 mg/100g) was the most abundant amino acid followed by arginine (3.27±0.03 g/100g) and glutamic acid (3.48±0.02 g/100g).

Table 3: Amino acid composition of water melon and cassava peels

Amino Acid	Cassava (g/100g)	Watermelon (g/100g)
Leucine	4.79±0.03 ^{cd}	4.03±0.05 ^d
Lysine	4.77±0.02 ^{cd}	2.39±0.05 ^{bc}
Isoleucine	3.08±0.04 ^c	3.21±0.02 ^c
Phenylalanine	1.42±0.03 ^b	2.66±0.01 ^{bc}
Tryptophan	0.73±0.04 ^a	0.74±0.03 ^a
Valine	3.62±0.05 ^c	3.21±0.05 ^c
Methionine	1.35±0.06 ^b	0.59±0.01 ^a
Proline	1.12±0.03 ^b	1.73±0.02 ^b
Arginine	8.43±0.05 ^f	3.27±0.03 ^c
Tyrosine	2.58±0.06 ^{bc}	2.06±0.03 ^{bc}
Histidine	2.11±0.05 ^{bc}	1.09±0.05 ^b
Cystine	0.73±0.04 ^a	0.60±0.03 ^a
Alanine	5.84±0.07 ^d	3.41±0.03 ^c
Glutamic acid	9.96±0.06 ^g	3.48±0.02 ^c
Glycine	5.70±0.05 ^d	2.33±0.06 ^{bc}
Threonine	1.22±0.05 ^b	2.16±0.02 ^{bc}
Serine	2.16±0.03 ^{bc}	1.62±0.01 ^b
Aspartic acid	6.70±0.03 ^e	3.22±0.02 ^c
Total	66.31±4.56	41.80±2.68

Data are Mean ± SEM of triplicate determination. Value with different superscript alphabet are significantly different (p <0.05)

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4.0 Discussion

The study showed that watermelon seed and cassava peel contain nutritious compounds. The present study showed carbohydrate is the most abundant proximate contents of both the cassava ($82.14 \pm 0.42\%$) and watermelon ($62.58 \pm 0.78\%$) peels. Results of the present study are in agreement with reported values of 62.0% and 72.50% (Somendrika *et al.*, 2017). Lower than values ranging from 87% to 89% (Akpabio *et al.*, 2012) and higher than values of 35.83% reported in other findings (Adegbola *et al.*, 2016). This generally shows that cassava peels are rich in sugar, which is a serious source of vitality in the animal feedstuff.

Moisture is an important parameter in the preservation of cassava flour; very high levels greater than 14% allow for microbial growth and therefore low levels are favorable and give a relatively long shelf life (Edet *et al.*, 2017). The cassava peel and watermelon peels in this study show good moisture levels and hence delivers the potential for better shelf life. Other findings show that the results obtained from this study are low (Akpabio *et al.*, 2012). The ash content is used as a benchmark to determine the mineral constituent (Olufunke *et al.*, 2010). This result shows that cassava peels and watermelon peel have low-fat content. These results correspond to values reported in other findings (Somendrika *et al.*, 2017). Nevertheless, these values were higher than those reported in another study (Okpako *et al.*, 2008). The fiber contents of cassava peel ($5.51 \pm 0.06\%$) obtained are comparatively lower to 21.1% as observed in the pulp and 8.2% in the peels, reported in another study (Ravindran *et al.*, 2008). These values were higher than reported values of (0.60 – 0.88%), but comparable with reported values in other surveys (Christopher *et al.*, 2016).

The high protein contents of watermelon and cassava peels could serve as a protein supplementary source in animal and human diets. This protein content is of particular nutritional significance since it has been suggested that amino acid supplementation is important in meeting a substantial proportion of an animal's protein and energy requirements (Doherty *et al.*, 2007). Proteins are also essential for continuous replenishment of the endogenous protein that is lost due to infections with gastro-intestinal helminths (Holmes, 1993).

It is also of remarkable interest that the cassava peel and watermelon peel have a high deposit of

mineral elements. The results obtained revealed that magnesium is the most abundant minerals contents of both the cassava ($79.50 \pm 4.45 \text{ Mg/100g}$) and watermelon ($75.53 \pm 3.70 \text{ Mg/100g}$) peel, followed by sodium ($62.35 \pm 0.79 \text{ Mg/100g}$ and $52.24 \pm 3.24 \text{ Mg/100g}$), potassium (22.12 ± 1.34 and $32.65 \pm 2.01 \text{ mg/100g}$) for both cassava and watermelon peels respectively while copper ($0.73 \pm 0.05 \text{ Mg/100g}$ and $0.67 \pm 0.64 \text{ Mg/100g}$) is the least minerals in both samples. Calcium is required for the formation and maintenance of bones and teeth thus, preventing osteoporosis. It is also needed for normal blood clotting and nerve function. Interestingly, even Fe, which is commonly deficient in many plant-based diets, was found in abundance in cassava peel and watermelon peel. Iron is a necessary component of hemoglobin and myoglobin for oxygen transport and cellular processes of growth and division (Rouault, 2006).

Iron is also an essential trace element for the normal functioning of the central nervous system and in the oxidation of carbohydrates, proteins, and fats (Fretham *et al.*, 2011). Iron also has a role in energy metabolism as it facilitates the transfer of electrons in the electron transport chain for the formation of ATP (Rouault, 2006). The presence of Zn in high amounts in watermelon and the cassava peel are of special interest in view of the importance of the inclusion of Zn in the diet of animals and humans (Fretham *et al.*, 2011). Zinc is essential for the synthesis of DNA, RNA, insulin, and function and/or structure of several enzymes Doherty *et al.*, 2007). Zinc is also required for cell reproduction and growth especially sperm cells. In addition, Zn is known for its anti-viral, antibacterial, anti-fungal, and anti-cancer properties (Doherty *et al.*, 2007).

The watermelon and cassava peels contained Cu, which is considered to have strong effects on the immune system (Djoko *et al.*, 2015). Copper is involved in stimulating the body's defense system, as it is active in neutrophil production and affects phagocyte killing ability (Wadas *et al.*, 2007). Copper in combination with Zn plays a role in superoxide dismutase activity and the removal of oxygen free radicals. It is, therefore, a key component in the protective mechanism of cellular membranes against superoxide free radicals damage (Chan *et al.*, 1998). In addition, the copper-containing enzyme, ceruloplasmin has been shown to exhibit anti-inflammatory activity, which may prove beneficial in mastitis cases (Chan *et al.*, 1998). Collectively, the mineral composition of watermelon and cassava peels will play a significant role in nutritional, medicinal, and therapeutic values, and thus worthy of exploration in animal diet

5.0 Conclusion

In conclusion, the peels of cassava and watermelon examined, have appreciable levels of nutrients compositions. The proximate, minerals, and amino acid analysis revealed that these peels are rich in nutrients especially in carbohydrates. It also contains significant amounts of minerals amino acid profile. With these findings, cassava and watermelon peels can be incorporated into animal feed formulation.

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