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# COMPARATIVE STUDY ON THE NUTRIENTS AND ANTI-NUTRIENTS COMPOSITION OF THE PEELS AND FLESH OF SWEET POTATO (*Ipomoea batatas* L.)

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## ABSTRACT

The increasing incidence of food shortages and nutritionally related diseases in the world has made it imperative to carry out nutritional studies on food materials. The proximate composition, minerals and vitamins, as well as the anti-nutrient constituents of the peels and flesh of sweet potato were determined. The peels were found to contain higher levels of crude protein (8.79 %), lipid (4.5 %), fibre (2.00 %) and ash (4.00 %) than the flesh (4.83 %, 0.1 %, 1.0 % and 3.0 % respectively) while the later had higher levels of moisture (71.29 %) and carbohydrate (91.07 %). The flesh was also higher in β-carotene (3.59 mg/100g) and vitamin A (4.30 IU) than the peels (1.26 mg/100g and 1.60 IU respectively), while the peels were higher in vitamin C (20.63 mg/100g). The peels were also found to contain higher levels of the minerals – iron (43.95 mg/100g), magnesium (20.63 mg/100g), manganese (0.07 mg/100g), calcium (40.41 mg/100g) and phosphorus (98.95 mg/100g) than the flesh (25.65 mg/100g, 2.11 mg/100g, 0.00 mg/100g, 16.84 mg/100g and 72.95 mg/100g respectively). The flesh had minimal levels of the anti-nutrient compounds - hydrocyanic acid (17.28 mg/100 g), tannins (385.19mg/100g), oxalate (total with soluble) (61.60 mg/100g) and phytate (557.26 mg/100g) while the peels showed higher levels of these compounds (21.60 mg/100g, 533.33 mg/100g, 433.60 mg/100g and 755.70 mg/100g respectively). Sweet potato tubers and peels are an excellent source of calories, vitamin C and beta carotene, with considerable amounts of protein and macro minerals. It is recommended that the peels of sweet potato be processed into animal feed and not discarded as garbage. Also, when properly processed to reduce anti-nutrient contents, the sweet potato peels can be consumed just as the flesh, thus can reduce malnutrition and other nutritional related diseases.

**KEYWORDS:** Sweet potato Peels and Flesh, Malnutrition, Anti-nutrients, Minerals, Vitamins.

## INTRODUCTION

Amidst the obvious stresses of food security including climate change, economic stress, and natural disasters (Ahmad *et al.*, 2021), the increasing incidences of food shortages and nutritionally related diseases in the world have made it imperative to carry out nutritional studies on food materials. Food security is sustained when food systems are flexible against these factors (Myers *et al.*, 2017). According to the Food and Agricultural Organization, food security entails that food must be available, accessible, affordable, and stable for the population and must meet the nutritional needs and food preferences for active healthy life (FAO, 2009)**.** Despite the rapid expansion and advances in agriculture to meet the food demand of the growing population, most people do not have access to good or nutritious foods and are grossly undernourished and malnourished. Food insecurity leads to crises such as hunger, malnutrition, and infection (Ahmad *et al.*, 2021), and there is a vicious cycle that exists between malnutrition and infection (Anker *et al.*, 2020; Burgos *et al.*, 2022). Consequently, there has been a global concern to address the issue of malnutrition vis-à-vis improving health by exploring some of the unconventional food materials like peels. This may be achieved by determining the nutrient composition of such food materials with a view to making recommendations to consumers on what and what not to eat and also to farmers and agriculturists on what to grow in order to have a well-nourished and healthy population.

Properly transformed food parts could offer a better outcome and minimize waste and given the myriad of phytonutrients in them, could be utilized as functional foods, a term used to describe foods that offer physiological benefits in addition to nutritional values they offer. The physiological benefits derived from food and food products are largely attributed to the abundance of secondary nutrients present in these foods, with well-elucidated mechanistic actions (Petroski and Minich, 2020; Dias *et al.*, 2021). Certain food crops contain abundant secondary metabolites such as flavonoids, polyphenolics, alkaloids, proteins, and peptides that have been demonstrated to be effective against infectious agents through overlapping mechanisms of action (Dias *et al.*, 2021). Phytochemicals from food parts have multifaceted therapeutic applications owing to their rich anti-inflammatory, antiviral, antioxidant, immunomodulatory, and antibacterial compounds (Bansal and Priyadarsini, 2021) that account for their varying mechanisms of action against infectious agents. In addition, these phytochemicals also have applications in the food processing industry. For instance, flavonoids are widely used as food additives as preservatives (Pateiro *et al.*, 2023), pigments, and antioxidants (Dias *et al.*, 2021).

Sweet potato (*Ipomoea batatas* L.), a root tuber and dicot plant belonging to the family *Convolvulacae* has gained importance among the major food crops in terms of dry matter production per hectare (FAO, 2021). It is one of the richest and cheapest sources of dietary energy, ranking as the fourth most important tuber crop after cassava (van Vugt and

Franke, 2018). Most cultivars of sweet potato have variations in colour of the peels ranging from yellow, cream, white to pink and flesh colours including purple, white, yellow, and orange (Rose and Vasanthakaalam, 2011; Joshi *et al.*, 2021). During processing, potatoes are always peeled off as waste with zero value but recent investigations reveal that these peels could be recycled to serve useful purposes. Potato flesh not only serves as food because of its rich supply of carbohydrates, dietary fibers, and minerals, (Martínez-Fernández *et al.*, 2021), but also possesses antioxidants, antimicrobial, anti-inflammatory, and anticancer activities to varying degrees depending on the variety (Yong *et al*., 2019). Sarker *et al.* (2020) found that sweet potatoes enhanced haematological indices. Peels of sweet potato tubers are important potential food sources in animal feeds Ibrahim and Olaniyi (2018), and its use could sustain food security (Franco *et al.*, 2021). Irrespective of variety, the use of potato peels could be applied in the production of biofilms, fertilizers and adsorbers (Torres *et al*. (2020), including applications in pharmaceuticals, biotechnology, and food industries (Javed *et al.*, 2019), owing to the abundance of phenolic compounds present in them (Wu *et al.*, 2012). Sweet potato peel wastes can be repurposed by extracting natural antioxidants for fortifying food systems in the food industry. Phenolic compounds confer several health benefits through their anti-carcinogenic, anti-microbial, anti-apoptotic (Sharif *et al.*, 2018), antioxidant and anti-mutagenic properties and anti-inflammatory mechanisms (Banerjee *et al.*, 2017; Riaz *et al.*, 2023).

Given the myriad of secondary metabolites present in potato peels, they could serve as important functional food sources and chemopreventive agents. However, there is a dearth of information on the anti-nutrient composition of sweet potato peels and flesh. This study aims to assess the nutritional and anti-nutrient make-up of sweet potato peels, in comparison with its flesh as an alternative in addressing malnutrition and enhancing wellbeing. Values obtained from the proximate analyses of sweet potato peels and flesh would be good indicators of the nutritive value of the food materials.

## MATERIALS AND METHODS

### Collection of Samples

The white flesh with cream coloured peel variety of sweet potatoes (*Ipomoea batatas* L.) were used for this study. All the samples of sweet potato used were purchased from Itak market in Ibiono Ibom, Akwa Ibom state, Nigeria. The tubers were all harvested not later than three days before purchase from the market and were transported to Biochemistry laboratory at the University of Uyo for processing and analyses.

### Treatment of Samples

The sweet potato tubers were first neatly washed with running water to remove debris, and then hand peeled (about 0.5 – 1 mm thick). Both flesh and peels were separately diced into smaller sections making up 4 kg each. The samples were separately air dried for 72 hours, then oven dried (Memmert oven) at 60 °C for 12 hours until constant weight. They were milled using laboratory blender (Model XC-03, Amani, China) to fine powder and sieved through 100 µm mesh. The fine samples were then labeled A and B each, representing the flesh and peels respectively. Samples were stored in air-tight containers until used for chemical analyses.

### Chemicals and Reagents

The chemicals and reagents used for this study were of analytical grade and from Sigma Aldrich Chemicals.

### Determination of Proximate Composition

Determination of moisture, ash, crude fiber, crude fat, and protein contents were done according to standard procedure of the Association of Official Analytical Chemists (AOAC, 2010). Moisture content was determined by heating to constant weight 2 g of the sample in a crucible placed in an oven and maintained at 100 °C. Ash was determined by placing 2 g of the samples in a muffle furnace maintained at 550 °C incineration for 4 hours. For crude fibre 2 g of samples was digested with $H_2SO_4$ and NaOH, followed by incineration of the residue in a muffle furnace maintained at 550 °C for 4 hours. Crude protein (using protein conversion factor) was determined by Kjeldahl method, while crude fat was carried out by Soxhlet extraction for 24 hours. Total carbohydrate was determined by subtracting the values obtained for crude fat, crude protein, ash, and crude fiber from 100. Total caloric value was done by multiplying the values obtained for crude protein, crude fat and carbohydrate by Atwater conversion factors 4, 9, and 4 respectively, and taking the sum of products (Omohimi *et al.*, 2017). The analyses were performed in triplicate trials.

### Determination of Anti-nutrients

The antinutrient factors of the samples which include hydrocyanic acid, tannin, phytate and oxalate were determined using the method as described by Onwuka (2005), with modification. All chemical analyses were performed in triplicate trials.

### Determination of Mineral Elements

The samples (1 g each) were digested by treatment with $HNO_3$ and $H_2O_2$ at 100 °C until completed, and diluted in deionized water. Sodium (Na) and potassium (K) contents were determined using Flame photometry, while phosphorus (P), iron (Fe), calcium (Ca), magnesium (Mg), and manganese (Mn) were determined through inductively coupled plasma atomic emission spectrophotometry (ICP-AES) using atomic-emission spectrometer (Optima 2500 DV, Perkin Elmer, USA). Digestion, preparation of standards and analysis of samples followed procedures as reported by Juhaimi *et al*. (2016), with modification. All chemical analyses were performed in triplicate trials.

### Determination of Vitamins and β-carotene Content

Vitamin C (as ascorbic acid) was determined by colorimetric method as employed by Senthilkumar *et al.* (2020) and the orange-red solution was measured at absorbance of 540 nm. β-carotene extraction and analysis followed the method described by Aremu and Nweze (2017), with some modifications. 1 g each of powdered samples was well mixed with 5 mL of distilled water. The mixture was then extracted in 25 mL of methanol in dark condition overnight

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at room temperature. The supernatant was centrifuged at 2000 rpm for 2 minutes to remove fine particles prior to analysis. The absorbance of the supernatant was measured at 480 nm using hexane as blank. The extraction and analysis procedure was done in triplicate trials. The β-carotene was calculated using the formula (Aremu and Nweze, 2017):

β-carotene (µg/100g) = Absorbance (480 nm) x V x D x 100 x 100/W x Y

where: V = volume of extract; D = dilution factor; W = weight of sample; Y = Percentage dry matter content of the sample.

The standard conversion formula was used for determination of vitamin A, using the retinol equivalent (RE) of beta carotene for sweet potato (FAO, 2001; Scotta and Rodriquez-Amaya, 2000).

**Ethical Consideration**
This study was approved by the Faculty of Basic Medical Science Ethics Committee of University of Uyo, Nigeria, prior to the fieldwork.

**Statistical Analysis**
In all cases, the data are recorded as mean values of triplicate trials. The means of anti-nutrients, minerals and vitamins were compared using one way Analysis of Variance (ANOVA), SPSS version 21. Duncan's Post Hoc multiple comparison test was carried out at 5 % level of significance.

## RESULTS
The data collected from this study were analyzed and the results obtained are shown in the tables. Table 1 shows the results of proximate analysis which revealed that the peels have percentage higher contents of crude protein, lipid, fiber, and ash than the flesh. However, values of moisture content and carbohydrate were noticed to be higher in the flesh than that of the peels.

Table 1: Proximate Analysis of *Ipeoma batatas* L. Peels and Flesh

| Proximate Composition | Peels (%) | Flesh (%) |
|---|---|---|
| Moisture content | 64.21 | 71.29 |
| Protein | 8.79 | 4.83 |
| Lipid (fat) | 4.50 | 0.10 |
| Carbohydrate | 80.71 | 91.07 |
| Fibre | 2.00 | 1.00 |
| Ash | 4.00 | 3.00 |

Values are mean of triplicate trials

Anti-nutrient estimation of the *Ipeoma batatas* L. peels and flesh showed that the peels have higher anti-nutrient composition than the flesh. The peels revealed significantly ($p < 0.05$) higher levels of phytate, oxalate (total and soluble) and tannin, and higher content of HCN (which was not significant ($p > 0.05$)) when compared to the flesh.

Table 2: Anti-nutrients in *Ipeoma batatas* L. Peels and Flesh

| Anti-nutrients | Peels (mg/100g) | Flesh (mg/100g) |
|---|---|---|
| Hydrocyanic acid (HCN) | 21.60 ± 0.00 | 17.28 ± 0.02 |
| Tannin | 533.33 ± 0.02* | 385.19 ± 0.01* |
| Phytate | 755.70 ± 0.03* | 557.26 ± 0.03* |
| Oxalate (total) | 325.60 ± 0.01* | 35.20 ± 0.02* |
| Oxalate (soluble) | 108 ± 0.12* | 26.40 ± 0.17* |

Values are mean ± SEM of triplicate trials values with superscript (*) are significantly different from each other in the other column

The estimation of mineral elements contents as shown in Table 3 showed the peels contain significant ($p < 0.05$) amount of Phosphorus (P), Iron (Fe) and Calcium (Ca) than the flesh. Also, the values of the two major minerals, sodium and potassium revealed higher contents for the flesh but were not significant ($p > 0.05$) when compared to the peels.

Table 3: Minerals Content of *Ipeoma batatas* L. Peels and Flesh

| Minerals | Peels (mg/100g) | Flesh (mg/100) |
|---|---|---|
| Sodium | 31.090 ± 0.30 | 34.32 ± 0.12 |
| Potassium | 18.47 ± 0.20 | 19.80 ± 0.17 |
| Phosphorus | 98.95 ± 0.00* | 72.95 ± 0.01* |
| Iron | 43.95 ± 1.00* | 25.65 ± 0.13* |
| Calcium | 40.41 ± 1.20* | 16.84 ± 0.00* |
| Magnesium | 2.63 ± 0.30 | 2.11 ± 0.01 |
| Manganese | 0.08 ± 0.00 | 0.00 ± 0.04 |

Values are mean ± SEM of triplicate trials
Values with superscript (*) are significantly different from each other in the other column

In the Table 4, as shown, the flesh contains significantly ($p < 0.05$) higher provitamin (β-carotene) and vitamin A contents than the peels. Also, vitamin C content for peels was higher than that of the flesh, but was not significant ($p > 0.05$).

Table 4: Vitamins and β-carotene Content of *Ipeoma batatas* L. Peels and Flesh

| Vitamins | Peels | Flesh |
|---|---|---|
| β-carotene (mg/100g) | 1.26 ± 0.31* | 3.59 ± 1.02* |
| Vitamin A (I.U) | 1,600 ± 0.12* | 4,300 ± 2.45* |
| Vitamin C (mg/100g) | 20.63 ± 0.01 | 16.90 ± 1.02 |

Values are mean ± SEM of triplicate trials
Values with superscript (*) are significantly different from each other in the other column

## DISCUSSION
The results of the proximate composition of the peels and flesh of the potato showed that the peels have higher crude protein, lipid, fiber, and ash contents than the flesh. This is in tandem with report by Zulkifli *et al*. (2021). On the other hand, composition analyses of both the flesh and peel showed that the flesh had more moisture (71.29 %) and carbohydrate (91.07 %) contents than the peel. Although there is a dearth of reports indicating peels containing more of these nutrients than the flesh in comparison, the report by Dako *et al.* (2016) suspected higher levels of crude protein,

fibre, and ash in the peels than the flesh. Carbohydrates are organic compounds that may be found in bacteria, plants, and mammals. Liang and McDonald (2014) found that potato peel contained starch and non-starch polysaccharides such as cellulose and pectin with peculiar structures that make them suitable for various uses. Because of their structure, they are commercially useful in bioplastics, paper, textile, and food industries (Sani *et al.*, 2021). Also, it has been reported that the polysaccharides in potatoes are biologically useful in the cell with potent anti-oxidative, anti-inflammatory, antitumor, antidiabetic, and anticoagulant capabilities (Jeddou *et al*. 2018). These findings suggest the potential of potato peels and flesh as a functional food and could be useful substitutes in the management of many oxidative stress and inflammatory-related chronic diseases.

Amino acids are monomers of protein and depending on the nutritional requirements could be classified as essential, non-essential, or semi-essential. The essential amino acids cannot be synthesized by the human body and therefore must be obtained from the diets. Our findings suggest that sweet potato peels contained more crude protein (8.79 %) than the flesh (4.83 %), making them an important food source of interest, and contributing to total energy supply (Yong *et al*. 2019). While investigating the amino acids in potatoes, Mushinskiy *et al.* (2021) found that potato flesh contains proteins with 18 amino acids with all 9 essential amino acids present. Although the flesh contains less amount of protein than the peel, it can contribute to protein intake due to the large amount of the flesh that is usually consumed. The amino acids in potato peels can participate in food deterioration by reacting with free sugars to produce browning products such as acrylamide (Rodríguez-Martínez *et al.*, 2021), a well-established neurotoxic agent in cells (Liu *et al.*, 2015). In another study, it was reported that the non-protein amino acids in potato peels elicited biological activities (Choi *et al.*, 2016). The research group found that β-alanine improves exercise performance and reduced fatigue in humans, and α-aminoadipic acid modulates glucose homeostasis in humans. They also reported that hydroxyserine strengthens the mechanical properties of human collagen tissues, and phosphoserine was reported to reduce Alzheimer's disease. These findings point to the need to consider utilizing potato peel as a functional food. Also, ENV/JM/MONO (2010) noticed higher crude protein, ash, and fibre in raw sweet potatoes with skin than without skin. In view of these, it is noteworthy that sweet potato peels and flesh are generally low in protein contents.

Sweet potato flesh has higher moisture and carbohydrate contents than the peels, with carbohydrates being the highest of the nutrients in this study. The moisture content of 71.29 % obtained for the flesh is similar to that reported by Adepoju and Adejumo (2015) who reported 69.80 % moisture content. Variations in moisture contents and other nutrients may be attributed to different varieties, environmental factors, and procedures of extraction at the time of analysis. This result also shows that the peels and flesh of sweet potatoes are capable of meeting the energy requirements of the body because they both have high caloric values. The caloric value of the peels is however higher than that of the flesh.

Anti-nutrients are synthetic or natural compounds in food that interfere with the availability of nutrients. They reduce nutrient intake, digestion, and utilization, thus reducing the nutritional value of foods and causing malnutrition (Essack *et al.*, 2017). The presence of phenolic compounds and other biologically important compounds in anti-nutrients makes them pharmacologically important and places them in the limelight of chemoprevention. Important anti-nutrients commonly found in foods include phytates, oxalates, phthalic acids, and tannins (Escobar-Sáez *et al.*, 2022). Many of these anti-nutrients act as enzyme inhibitors (Tysoe *et al.*, 2016), while others are chelators of important minerals (Priyodip *et al.*, 2017). Importantly, anti-nutrients play important defensive roles in the plants and help to ward off predators (López-Moreno *et al.*, 2022). Anti-nutrient estimation of the peels and flesh revealed the peels had significantly ($p < 0.05$) higher levels of phytate, oxalate and tannin contents, with non-significantly ($p > 0.05$) higher contents of HCN, than the flesh (Table 2). Tannins have been reported to exhibit anti-nutritional properties by impairing the digestion of various nutrients and preventing the body from absorbing beneficial bioavailable substances (Hendek and Bektas, 2018). Tannin inactivates digestive enzymes by forming complexes with protein and inhibits the digestion of protein (Yuan *et al.*, 2020). Phytates reduce the bioavailability of minerals such as iron, zinc, magnesium, and calcium by forming a complex with them (Akter *et al.*, 2020). These minerals are important cofactors for digestive enzymes and their lower bioavailability may result in the inactivation of these enzymes such as amylase, trypsin, etc. Oxalic acid complexes with minerals to form soluble or insoluble salts called oxalates (Akter *et al.*, 2020), which can have deleterious effects on health. Calcium oxalate can cause kidney stones (Mitchell *et al.*, 2019). Furthermore, our results show that potato peels had a comparatively higher level of hydrocyanic acid than the flesh (Table 2.). Agubosi *et al*. (2022) reported the presence of cyanogenic glycosides in air-dried potato peels and this is consistent with our result. Exposure to cyanide is linked to cyanide poisoning and can cause damage to the central nervous system (Hariharakrishnan *et al.*, 2010). Our results suggest that the flesh may not have deleterious effects when consumed or included in an animal's diet as feed. The presence of these anti-nutrients in the potato peels implies that caution must be taken when consuming the peels. Ibrahim and Olaniyi (2018) recommended the inclusion of some levels of peel meal of less than 15 % as a replacement for maize on the growth performance of rabbits due to the toxic nature of the sweet potato peels.

Physiological functions of the human body depend on the cardinal roles minerals play in metabolic processes, which may have health implications when in deficient supply (Abbaspour *et al.*, 2014). Mineral elements estimation conducted in this study showed the peels having significant ($p < 0.05$) contents of Phosphorus (P), Iron (Fe) and Calcium

(Ca) than the flesh. Although sodium and potassium contents for the flesh revealed non-significant ($p > 0.05$) higher values than the peels, both (flesh and peels) show increased values of the two major minerals. Higher values obtained for phosphorus, Sodium, potassium, and calcium in flesh are in line with the findings of Antonio *et al.* (2011). Lower levels of Magnesium (Mg) and Manganese (Mn) were noticed in both peels and flesh, which corresponds to the report by Agubosi *et al.* (2022) and Krochmal-Marczak *et al.* (2014) for peels and flesh respectively.

Vitamins are essential food factors which play significant roles in human body physiology and normal health. However, deficiencies resulting from reduced intakes have adverse effects on normal metabolic processes. β-carotene is a provitamin A carotenoid from green, yellow and orange vegetables such as sweet potatoes, carrots and spinach. The body converts this provitamin to its active vitamin A form. Animal sources may include dairy products, beef liver, eggs etc (NIH, 2022). Regular consumers of Beta-carotene (β-carotene) or vitamin A have a lower incidence of certain types of cancer (NIH, 2022). β-carotene estimation carried out in this study showed that the flesh had significantly ($p < 0.05$) higher β-carotene contents than the peels. Also, vitamin A estimation showed that the flesh have significantly ($p < 0.05$) higher vitamin A content than the peels. The content of vitamin A in vegetables like sweet potatoes increases with maturity (USDA, 2016). The value obtained for the flesh (4,300 I.U) is capable of meeting the recommended dietary allowance (RDA) for adult males and females, set at 3000 I.U and 2333 I.U respectively (Ross and Moran, 2020; NIH, 2023). This therefore translates that the flesh is a rich source of β-carotene and the peels may require additional consumption. If eaten regularly, both sweet potato peels and flesh can meet the RDA of β-carotene and vitamin A. Vitamin C otherwise called ascorbic acid is a powerful antioxidant which enhances would healing, capillary health and maintains normal connective tissue (Opara *et al*., 2017). Vitamin C values of 16.90 mg/100g and 20.63 mg/100g for the flesh and peels in this study is similar to that of Senthilkumar *et al.* (2020) who reported 17.29 mg/100g for the flesh. However, our findings differ from those reported by Adepoju and Adejumo (2015) and Ibrahim and Olaniyi (2018) for flesh and peels, respectively. Hence, it can be gathered that the vitamin C content of sweet potato flesh falls in the range of 16.13 mg/100g to 24.20 mg/100g. These values may be altered by processing methods, genetic and environmental influences.

## CONCLUSION

Sweet potato tubers and peels are an excellent source of calories, vitamin C and beta carotene, with considerable amounts of protein and macro minerals such as sodium, potassium and phosphorus, sufficient enough for optimum growth and development of the body. The peels of sweet potato can be processed into animal feed and not discarded as garbage, especially when energy requirement is utmost. Also, sweet potato peels can be consumed by humans when properly processed to reduce the toxic contents. Thus, it can reduce malnutrition and certain nutritional related diseases just like the flesh. However, further research is needed to demonstrate and compare the anti-nutrient composition in different varieties of potatoes, and the possible utilization of potato peels as potential foods.

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