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Antinutrient Profiling of Orange and White Flesh Sweet Potato Peel and Flesh: Implications for Human Health and Optimal Food Processing Strategies

Nwankwo Victor Ugadu[1], Nwabueze Chibuzo Victoria[2]
[1.] *Department of Biotechnology, Ebonyi State University, Abakaliki, Nigeria*
[2.] *Computer Science Department Federal College of Land Resource Technology, Owerri Imo State.*
Corresponding author: vicnwankwo1975@gmail.com
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Abstract: Potatoes play a crucial role as a fundamental and cost-effective staple food in Nigeria, with their nutritional content being influenced by various factors such as the potato variety, and processing methods. This research study assesses the anti-nutrients in different potato varieties and their peels. The findings reveal that potato peels exhibit elevated levels of flavonoids and anthocyanins, followed by polyphenols. Additionally, they contain minor quantities of tannins, oxalates, saponins, and alkaloids. White flesh sweet potatoes such as EBSA1, EBSA2, and EBSA3 had higher concentrations of all the antinutrients in both flesh and peels compared to the o Orange-Fleshed Sweet Potatoes (OFSP) such as NRCR5, NRCR7, NRCR9, NRCR13, NRCR17, and NRCR18. The anti-nutrients in the peels were significantly higher than in the flesh in all the samples. The levels of antinutrients in potatoes especially the peels showed that eating potato peels has health-benefiting compounds more than the flesh.

I. Introduction

The extent and sharp transformation in sweet potatoes' cultivation and consumption patterns, specifically the shift from Traditional, White-Fleshed Sweet Potatoes (WFSP) to Orange-Fleshed Sweet Potatoes (OFSP), seems an understatement. This transition has been particularly notable in, Nigeria, where WFSP cultivars, once prevalent among local farmers, have seemingly dwindled in popularity due to the emergence of OFSP varieties acclaimed to be rich in beta-carotene and carotenoids. Historically, WFSP cultivars held a significant presence in the agricultural landscape of NIGERIA known for their high yield and consumer acceptance despite their lower beta-carotene content compared to OFSP. However, the introduction of OFSP, renowned for its abundance of beta-carotene, a vital precursor to vitamin A, has led to a rapid displacement of WFSP cultivars among both farmers and consumers. This shift, driven by the perceived health benefits of OFSP in preventing conditions like night blindness, has reshaped the local sweet potato market and consumption habits. While the superiority of OFSP in terms of beta-carotene content is widely acknowledged, there remains a dearth of comprehensive studies comparing the overall antinutritional profiles of WFSP and OFSP cultivars, especially on potato peels since potato peels are sometimes eaten together with the flesh or separate. This knowledge gap is crucial in understanding the broader implications of this agricultural transition beyond beta-carotene levels. Sweet potato peel, in general, has long been a staple food source for many communities in Nigeria, particularly for those facing food insecurity. Rich in protein, dietary fiber, polyphenols, vitamins, and minerals, sweet potato peels offer a nutrient-dense alternative to staple crops like cassava, maize, rice, and wheat. The global significance of sweet potatoes as a vital food crop cannot be overstated, with over 110 million metric tonnes produced annually, making it the fifth most important food crop in the developing world. The nutritional composition of sweet potatoes, coupled with their low-fat content, positions them as an ideal food source for a large segment of the global population. This nutritional profile, combined with the adaptability of sweet potatoes to diverse growing conditions, underscores their importance in addressing food security challenges and improving dietary diversity. In conclusion, the transition from WFSP to OFSP in Nigeria reflects a broader trend in the agricultural sector towards crops with enhanced nutritional profiles. While the benefits of OFSP in terms of beta-carotene content are clear, a comprehensive evaluation of the nutritional and antinutritional properties of different sweet potato cultivars is essential for informing agricultural practices, dietary recommendations, and food security initiatives.

II. Materials and Methods

2.1. Materials, experimental site, design and agronomic practice

Nineteen cultivars of Orange-Fleshed sweet potato (OFSP) genotypes were collected from the National Root Crop Research Institute (NRCRI) in Umudike, Abia State, Nigeria. Among these cultivars, nine had purple skin and yellow flesh, including 'NRCR6', 'NRCR17', 'NRCR28', 'NRCR8', 'NRCR13', 'NRCR26', 'NRCR10', and 'NRCR16'. Four cultivars, 'NRCR3', 'NRCR2', 'NRCR4', and 'NRCR9', had red skin and yellow flesh. Additionally, six genotypes with brown skin and yellow flesh were identified, namely 'NRCR29', 'NRCR19', 'NRCR11', 'NRCR5', 'NRCR18', 'NRCR7', 'NRCR15', 'NRCR14', and 'NRCR20'. Furthermore, three traditional, white-fleshed sweet potato cultivars with different skin colors were collected from farmers in Nigeria Ebonyi State, Nigeria: 'EBSA1' (red skin), 'EBSA2' (light purple skin), and 'EBSA3' (white skin). The stem cuttings of all these cultivars were planted at the research and teaching farm of the Department of Crop Production and Landscape Management, Ebonyi State University, Nigeria Nigeria, during the rainy season in June 2019, with the growing period lasting until September of the same year. The experimental design was a randomized complete block design with three replicates. Standard agronomic practices were followed, including weeding and the application of NPK 20:10:10 fertilizer, fungicides (mancozeb/chlorothalonil), and insecticides (malathion1/cypermethrin) according to the recommended rates on the labels. Tuber weighing 10 kg was harvested from each cultivar for nutritional analysis. The tubers were washed, sliced, and freeze-dried. The dried potato slices were then pulverized, sieved through a 100-mesh sieve, and stored at –20°C for analysis. The laboratory analysis was conducted at the NRCRI central molecular biology laboratory in Umudike. A summary and description of each sweet potato tuber are presented in Table 1 below.

Table 1. Description of 21 sweet potato cultivars

S/N	Genotypes	Sources	Sowing/Harvesting date	Skin and flesh color
1	'NRCR6'	NRCRI	June.15, 2021/September15 ,2021	purple/yellow
2	'NRCR1'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
3	'EBSA3'	IKWO	June.15, 2021/ September 15 ,2021	White/white
4	'NRCR17'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
5	'NRCR8'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
6	'NRCR28'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
7	'NRCR13'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
8	'NRCR26'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
9	'NRCR10'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
10	'NRCR16'	NRCRI	June.15, 2021/ September 15 ,2021	purple/yellow
11	'NRCR29'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/Yellow
12	'NRCR19'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
13	'EBSA2'	IKWO	June.15, 2021/ September 15 ,2021	Light purple/white
14	'NRCR11'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
15	'NRCR5'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
16	'NRCR18'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
17	'NRCR7'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
18	'NRCR15'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
19	'NRCR14'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
20	'NRCR20'	NRCRI	June.15, 2021/ September 15 ,2021	Brown/yellow
21	'NRCR3'	NRCRI	June.15, 2021/ September 15 ,2021	Red/yellow
22	'EBSA1'	IKWO	June.15, 2021/ September 15 ,2021	Red/White
23	'NRCR2'	NRCRI	June.15, 2021/ September 15 ,2021	Red/yellow
24	'NRCR4'	NRCRI	June.15, 2021/ September 15 ,2021	Red/yellow
25	'NRCR9'	NRCRI	June.15, 2021/ September 15 ,2021	Red/yellow

NRCRI: National Root Crops Research Institute, Umudike, Abia State, Nigeria

2.2. Extraction of phenolics and flavonoids

The determination of total phenolics and flavonoids in freeze-dried, Orange-Fleshed Sweet Potato (OFSP) and White-Fleshed Sweet Potato (WFSP) roots involved a colorimetric assay following Abidemi's method (2013). Samples were weighed and placed in propylene tubes, mixed with 80% methanol, vortexed, and shaken for 12 hours at 25°C. After centrifugation, the supernatant containing the extracted compounds was collected for analysis to quantify total phenolics and flavonoids.

2.3. Determination of the total polyphenol content
The total phenolic content was quantified using the Folin-Ciocalteu technique following Baba and Malik's method (2015). Samples, gallic acid standards, and blank solutions were pipetted into test tubes, mixed with Folin-Ciocalteu reagent and sodium carbonate, and incubated for 90 minutes at room temperature. The absorbance at 725nm was measured using a spectrophotometer. The concentration of total phenolic compounds in mg/kg of the dry sample as Gallic Acid Equivalent was determined through an external standard calibration procedure.

2.4. Analysis of flavonoids
In the analysis of flavonoids, 0.005kg of each plant sample was weighed into a 250mL titration flask. 100mL of 80% aqueous methanol was added, and the mixture was agitated in an electric shaker for 4 hours at room temperature. The solution was filtered through Whatman filter paper no. 42, and the filtrate was evaporated to dryness in a crucible over a water bath before being weighed.

2.5. Analysis of tannin
Tannin analysis, following the method of Ejikeme et al. (2014), involved weighing 0.001kg of samples into a plastic bottle and adding 1000mL of water. The mixture was shaken for 1 hour, filtered, and 10mL of the extract was combined with 3mL of 0.1N HCl and ferrocyanide in a test tube. After standing for 10 minutes, the solution was measured in a UV-Spectrophotometer at a wavelength of 605nm to determine tannic acid concentration.

$$\text{Tannic acid (mg /kg)} = \frac{C \times \text{extract volume} \times 0.1}{\text{Aliquot volume} \times \text{weight of the sample}}$$

Where,
C is the concentration of tannic acid read.
2.6. Extraction and determination of oxalate
The extraction of total oxalate, following the methods of involved adding 1g of powdered sample to 0.5 mol.L^-1 HCl and diluting it in 1mL distilled water. The homogenate was heated in a boiling water bath for 20 minutes, cooled, and centrifuged the next day. NaOH was added to the supernatant, and oxalate oxidase was introduced into a test tube with other reagents. The absorbance at 555nm was measured in a spectrophotometer after 90 minutes of incubation to calculate oxalate content using a standard curve with known concentrations of oxalic acid. The results were reported as mean mg oxalate/kg.

2.87 Saponin analysis
Saponin analysis, following the methods of Akpe et al. (2021), involved adding 0.005kg of the sample to 50mL of 20% ethanol in a beaker. The suspension was heated for four hours at 60°C in a hot water bath with constant stirring. After filtration, the residue was re-extracted with another 25mL of 20% ethanol. The combined extract was concentrated to 40mL at 90°C, and diethyl ether was added and shaken. The aqueous layer was recovered, and n-butanol was added. The extract was washed with 5% aqueous sodium chloride, evaporated in a water bath, dried in an oven to a constant weight, and then weighed.

2.8. Alkaloids analysis
To analyze alkaloids, 5g of the sample was weighed into a beaker, and 100mL of 100% acetic acid in ethanol (1:1) was added and left covered for 4 hours. The extracted sample was then filtered and concentrated using a water bath. Ammonia solution was added drop by drop to the concentrated extract, allowing the precipitate to settle. The mixture was filtered, washed with dilute ammonium hydroxide, and the crude alkaloid was extracted from the residue. Finally, the extracted alkaloid was dried in an oven and weighed.

2.9. Anthocyanin analysis
To determine the total anthocyanin content, the method of Giusti and Wrolstad (2001) and Wegdan et al. (2020) was followed. Two dilutions of the sample extract were prepared by adding 1mL of the extract to separate 10mL volumetric flasks. One dilution was adjusted with potassium chloride buffer (pH 1.0), and the other with sodium acetate buffer (pH 4.5). After allowing the dilutions to equilibrate for 15 minutes, their absorbance was measured at 510 and 700 nm against water. The absorbance values were then used to calculate the total anthocyanin content.
A = (A510– A700) pH 1.0 – (A510– A700) pH 4.5
The concentration of monomeric anthocyanin pigment, specifically cyanidin-3-glucoside, was calculated using the formula: Monomeric anthocyanin pigment (mg/100g) = (A x MW x DF x 1000)/ (εx1), where MW (molecular weight) is 449.2 and ε (molar absorptivity) is 26,900. The dilution factor (DF) and absorbance (A) values were used in this formula to determine the pigment content in the sample as cyanidin-3-glucoside.

III. RESULTS AND DISCUSSION

The evaluation of anti-nutrients in both white-fleshed sweet potatoes (WFSP) and orange-fleshed sweet potatoes (OFSP) peels and flesh yielded significant insights. The study presents detailed data on the levels of various anti-nutrients found in the flesh and peels of these potatoes. Understanding these levels is essential for assessing the nutritional profile of potatoes and the potential health effects related to their consumption (Hamouz, *et al*.,2011; Jansen and Flamme 2006). Fresh potatoes are known for their abundance of beneficial compounds such as flavonoids, anthocyanins, and polyphenols. Conversely, they contain only minimal amounts of anti-nutrients like oxalates, saponins, tannins, and alkaloids (Dvořákand Čepl 2009; Rodriguez-Saona et al., 1998; Albishi et al., 2013; Brown 2005) The process of peeling potatoes is particularly effective at reducing these anti-nutrients, which improves the nutritional quality of the tubers. Potatoes are a vital and cost-effective dietary staple in Nigeria. However, their nutritional composition can vary based on several factors, including the type of potato, the location of cultivation, fertilization methods, and local climate conditions. This study takes these variables into account by analyzing the nutritional profiles of different potato varieties and their peels. By assessing the anti-nutrient content in both the flesh and peels of potatoes, this research provides valuable information that can help optimize their health benefits and guide dietary recommendations. The findings underscore the importance of processing methods, such as peeling, in enhancing the nutritional value of potatoes and highlight the need for ongoing research into the factors influencing their nutrient composition (Rodriguez-Saona *et a*l., 1998). The result of this study revealed that potato peels and flesh exhibit a high concentration of flavonoids, followed by anthocyanins, and polyphenols. Additionally, the analysis indicates low levels of tannins, oxalates, saponins, and alkaloids in the peels. Furthermore, the study highlights variations in anti-nutrient levels among different potato varieties. Specifically, certain varieties such as EBSA1, EBSA2, EBSA3, and NRCR29 demonstrate higher nutrient content in their peels compared to others, while varieties like NRCR5, NRCR7, NRCR9, NRCR13, NRCR17, and NRCR18 exhibit lower levels of anti-nutrients.

Potato peels are notably rich in dietary fiber and polyphenols, which are essential for a healthy diet. Research by Friedman (2007) indicates that nearly 50% of the phenolic compounds are concentrated in the peels and adjacent tissues, with these levels decreasing as one moves towards the center of the tuber. Fresh potatoes themselves are nutritionally valuable, containing substantial amounts of flavonoids, anthocyanins, , and polyphenols (Ogah et al.,2014). They typically have minimal amounts of anti-nutrients such as oxalates, saponins, tannins, and alkaloids. Certain potato varieties exhibit significant variation in their anti-nutrient content. For instance, varieties such as EBSA1, EBSA2, EBSA3, NRCR11, NRCR19, NRCR26, and NRCR29 are noted for their higher anti-nutrient levels, as illustrated in Figures 1 and 2. In contrast, varieties like NRCR6, NRCR7, NRCR9, NRCR13, NRCR17, and NRCR18 show lower anti-nutrient concentrations. This variation underscores the nutritional significance of both the peels and particular potato cultivars, highlighting their potential health benefits and the need for careful cultivar selection.

Comparing fresh and peeled potatoes reveals that peels contain higher concentrations of flavonoids, polyphenols, and anthocyanins. These beneficial compounds are more concentrated in the peels than in the flesh of fresh potatoes (Figure 3and 4). However, the levels of anti-nutrients such as oxalates, saponins, tannins, and alkaloids are minimal and remain relatively consistent in both fresh and peeled forms. Processing methods, including peeling, cutting, and washing, significantly impact the nutritional content of potatoes. According to Lisinska et al. (2009), the content and ratio of various components in potatoes change during these processes. Peeling and cutting often release beneficial compounds and can increase the proportion of insoluble substances in dried potatoes. Although removing anti-nutritional components, such as nitrates, is advantageous, it can also result in the loss of valuable nutrients, thereby reducing the overall nutritional quality of the tubers. Peksa (2006) emphasizes that most anti-nutrient compounds are located in the skin, just beneath it, and around the eyes of the potatoes. Therefore, pre-processing steps like peeling are effective in removing a significant portion of these unwanted substances (Rytel et al., 2005). This illustrates the need for optimizing processing techniques to strike a balance between eliminating anti-nutrients and preserving the nutritional benefits of potatoes. Understanding the distribution and impact of these compounds is crucial for improving processing methods and maximizing the health benefits of potato consumption. By refining processing techniques and making informed choices about potato varieties and preparation methods, it is possible to enhance the nutritional value of potatoes while mitigating potential health risks associated with anti-nutrients.

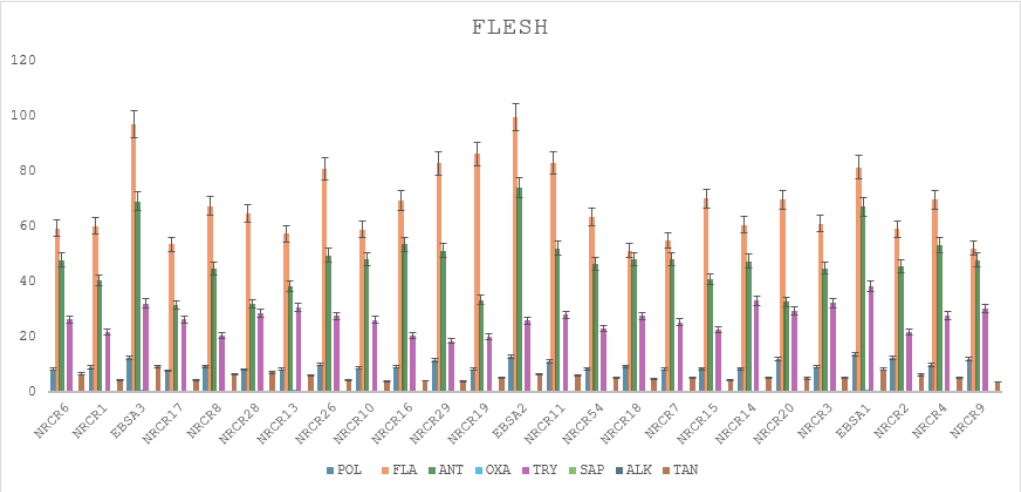

Fig 1. Anti-nutrients composition of potato peels

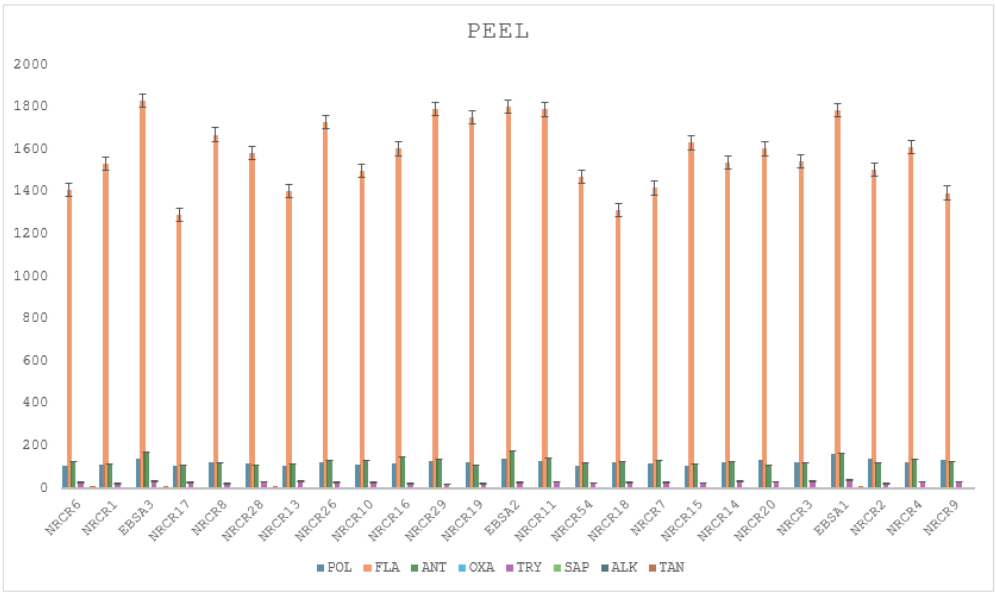

Fig. 2. Evaluation of flesh potatoes

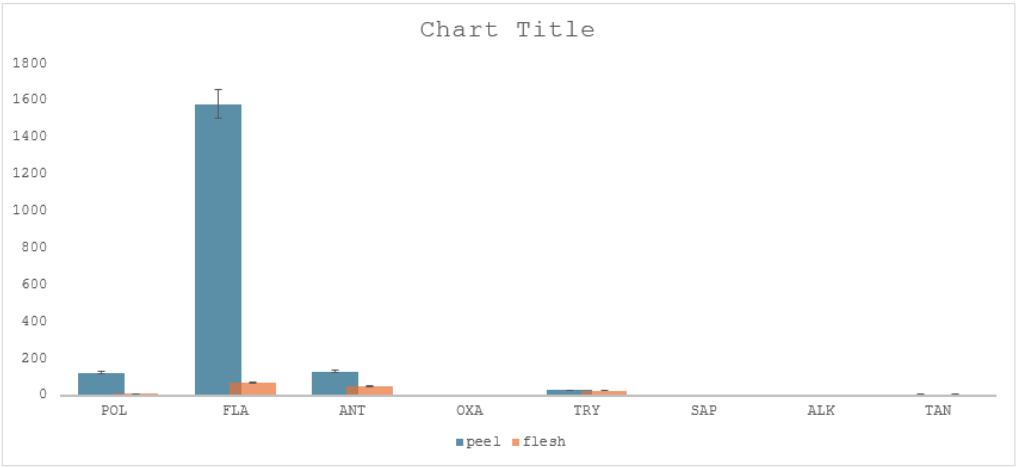

Fig. 2. Evaluation of potatoes and Peels

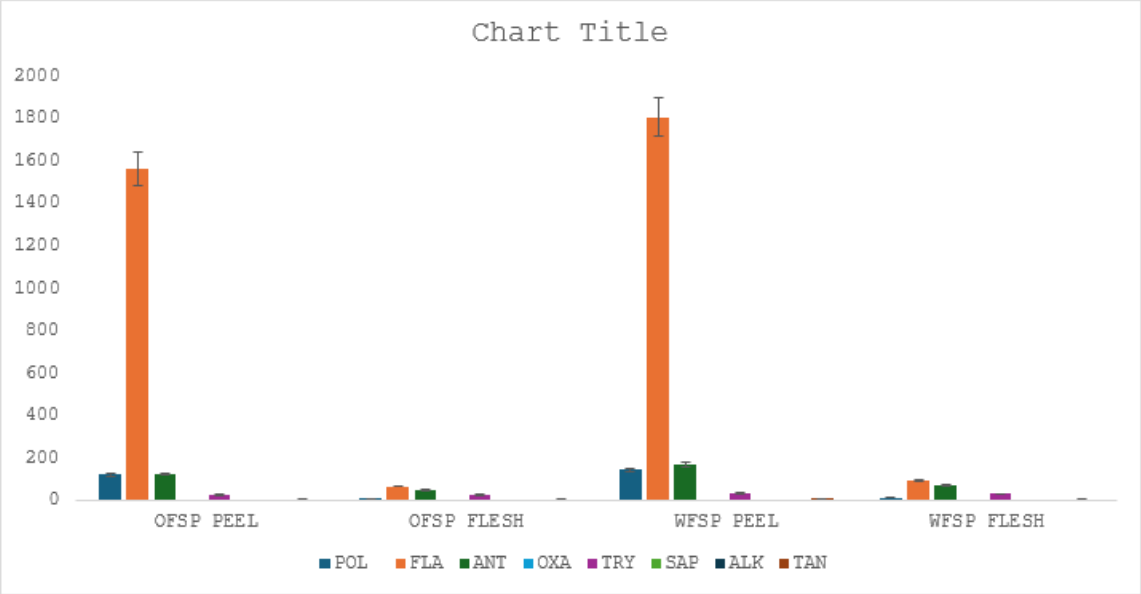

Fig. 3. Evaluation of Anti-Nutrient Levels in Orange-Fleshed and White-Fleshed Sweet Potato Peels and Flesh

IV. CONCLUSION

The study uncovered notable differences in antinutrient levels between TWFSP and OFSP cultivars and also in their peels. This suggests that TWFSP may offer greater nutritional and health benefits. However, except for alkaloids and anthocyanins, WFSP cultivars exhibited higher levels of all antinutrients compared to their OFSP counterparts.

REFERENCES

[1]. Akpe, M. A., Ashishie, P. B., & Akonjor, O. A. (2021). Evaluation of some phytochemicals in raw and cooked Ipomea batatas (Lam.), (Sweet Potato), Solanum tuberosum (Irish Potato) and Dioscorea cayenensis (Yellow Yam). Journal of Applied Sciences and Environmental Management, 25, 1563- 1567. https://doi.org/10.4314/jasem.v25i9.3

[2]. Albishi, T., John, J. A., Al-Khalifa, A. S., and Shahidi, F. (2013). Phenolic content and antioxidant activities of selected potato varieties and their processing by-products. J. Funct. Foods, 5, 590-600

[3]. Brown, C. (2005). Antioxidants in potato. Am. J. Potato Res., 82, 163-172

[4]. Baba, S. A., & Malik, S. A. (2015). Determination of total phenolic and flavonoid content, antimicrobial and antioxidant activity of a root extract of Arisaema jacquemontii Blume. Journal of Taibah University for Science, 9, 449–454. https:// doi.org/10.1016/j.jtusci.2014.11.001

[5]. Ejikeme, C. M., Ezeonu, C. S., & Eboatu, A. N. (2014). Determination of physical and phytochemical constituents of some tropical timbers indigenous to Niger Delta area of Nigeria. European Scientific Journal, 10(18), 247–270. https://doi.org/10.19044/esj.2014.v10n18p%pDvořák, P., and Čepl, J. (2009). Cultivar differences of total anthocyanins and anthocyanidins in red and purple-fleshed potatoes and their relation to antioxidant activity. Food Chem., 114, 836-843.

[6]. Guisti, M. M., & Wrolstad, R. E. (2001). Characterization and measurement of anthocyanins by UV-Visible spectroscopy. Current Protocols in FoodAnalytical Chemistry, (F1.21- F1.2.13). https://doi.org/10.17311/tasr.2020.179.186

[7]. Hamouz, K., Lachman, J., Pazderu, K., Tomasek, J., Hejtmánková, K., and Pivec, V. (2011). Differences in anthocyanin content and antioxidant activity of potato tubers with different flesh colour. Plant Soil Environ., 57, 478-485.

[8]. Jansen, G. and Flamme, W. (2006). Coloured potatoes (Solanum Tuberosum L.) - Anthocyanin content and tuber quality. Genet. Resour. Crop Evol., 53, 1321-1331

[9]. Lisinska, G., Peksa, A., Kita, A., Rytel, E. and Tajner – Czopk, A. (2009). The quality of potato for processing and consumption. Inc; yee N, Bussel W (Eds.), potato IV. Food (special issue 2), 99-104

[10]. Liu, E. E., Luo, W., Zhou, H., & Peng, X. X. (2009). Determination of oxalate in plant tissues with oxalate oxidase prepared from wheat. Biologia Plantarum, 53, 129–132. https://doi. org/10.1007/s10535-009-0018-y

[11]. Nguyễn, H. V. H., & Savage, G. P. (2013). Total, soluble and insoluble oxalate contents of ripe green and golden kiwifruit. Foods, 2, 76–82. https://doi.org/10.3390/foods2010076

[12]. Ogah, O., Watkins, C. S., Ubi, B. E., & Oraguzie, N. C. (2014). Phenolic compounds in Rosaceae fruit and nut crops. Journal of Agricultural and Food Chemistry, 62(39), 9369–9386. https://doi.org/10.1021/jf501574qPeksa, A., Golabowska, G., Aniolowski, K., Lisinska, A. and Rytel, E. (2006). Changes of glycoalkaloids and nitrate compounds in potatoes during chips processing. Food Chemistry 27;157-159

[13]. Rytel, E., Golubowska, G., Lisinska, G., Peksa, A. and Aniolowski K. (2005). Changes in glycoalkaloids and nitrate content in potatoes during French fries processing. Journal of Science of Food and Agriculture, 85: 879-882.

[14]. Rodriguez-Saona, L. E., Giusti, M. M., and Wrolstad, R. E. (1998). Anthocyanin pigment composition of red-fleshed potatoes. Journal of Food Science, 63, 458-465.

[15]. Wegdan, A. S., Md, S. A., & Tanveer, A. (2020). Extraction and estimation of anthocyanin content and antioxidant activity of some common fruits. Trends in Applied Sciences Research, 15, 179-186. https://doi.org/10.3923/tasr.2020.179.186