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Research article

Biochemical and antioxidant properties of cream and orange-fleshed sweet potato

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ABSTRACT

The rate of micronutrient deficiency has been on an increase since the last decade and the utilization of bio-fortified crops could help to alleviate this deficiency and food insecurity in Africa especially in Nigeria. The aim of this study was to compare the biochemical and antioxidant properties of cream-fleshed and orange-fleshed sweet potato. The varieties of OFSP used in this study were mother's delight (MDP) and king J (KJP) orange-fleshed sweet potato while the other variety was cream-fleshed sweet potato (CFSP). The tubers were processed into flour and analyzed for proximate, minerals, anti-nutrient and antioxidant properties using standard methods. The ash content ranged from 4.60 to 7.20%, carbohydrate content ranged between 73.47 and 78.61%. MDP has the highest beta carotene content with 18.83 mg/100g followed by KJP and CFSP. Magnesium value ranged between 124.0 and 148.2 mg/100g, potassium ranged from 1226.5 to 2350.0 mg/100g. Sodium-potassium ratio (Na/K) was <1. The antioxidants properties evaluated were all higher in OFSP than CFSP. The bio-fortified sweet potato showed an improved biochemical and antioxidant properties compared to the CFSP, thus OFSP will be suitable to combat micronutrient deficiency and food insecurity in Africa.

1. Introduction

Food bio-fortification is an agricultural process of proliferating the nutritional value of food crops by increasing both the quantity and quality of micronutrient (i.e. vitamins and minerals) in the crop either through conventional plant breeding; agronomic practices or biotechnology methods (AV, Weedo and Finckh 2019; Brouwer, 2019; Manjeru et al., 2019). Food crop that has been successfully bio-fortified includes sweet potato, maize, rice and cassava etc. This agricultural process is one of the foremost solutions among numerous interventions that are desirable to solve the multifaceted problem created by micronutrient malnutrition (Allen and De Brauw, 2019).

Sweet potato (*Ipomoea batatas* Lam.) is a dicotyledonous tuberous plant of *convolvulaceae* family. It is an important staple crop (Low et al., 2017); it thrives in the tropical, subtropical and in some temperate regions of the developing world (Alam et al. 2016). It has a short growing cycle of four (4) to five (5) months into maturity. Sweet potato is cultivated extensively for its nutritious value across many regions of the world, it is precisely known to contain significant amount of vitamins, minerals and antioxidants (Kunyanga et al., 2012). The varieties of sweet potato depends on either their skin, flesh colour and even both. Its colour ranges from orange, red, purple, yellow, brown, cream and white (Adebisi et al., 2015). Sweet potato with either orange colour on its skin or flesh is known as orange-fleshed sweet potato (OFSP) as it is presented in Table 1 and shown in Figure 1.

OFSP is a bio-fortified variety of sweet potato with high beta (β) carotene which is a precursor of vitamin A, that is OFSP is a pro-vitamin A food crop (Júnior et al., 2018; Tumuhimbise et al., 2019; Azeem et al., 2020). Beforehand, researchers has worked tremendously on OFSP: Adebisi et al. (2015) worked on its utilization, Alam et al. (2016) gave a report on the proximate composition and carotenoid contents of the different varieties of OFSP in Bangladesh, while Tiruneh, Urga, Tassew and Bekere (2018) gave a reported on the biochemical compositions and functional properties of orange-fleshed sweet potato variety in Hawassa, Ethiopia. Other report on OFSP by researchers includes Oloniyo et al. (2020); Omoba et al. (2020); Ruttarattanamongkol et al. (2016); Tumuhimbise et al. (2019) among others but there is a dearth of information on the biochemical and antioxidant properties of cream and orange-fleshed sweet potato thus, this research aimed to fill in the gap.

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Table 1. Characteristics of sweet potato used.

Characteristics	A	B	C
Varietal name	UMUSP001	UMUSP002	Hannah
Research Name	KJP	MDP	CFSP
Common name	King J	Mother's delight	Cream
Skin colour	Purple	Orange	Light Cream
Flesh colour	Light Orange	Dark Orange	Deep Cream

Key:
A - KJP- King J Orange-fleshed Sweet Potato (UMUSP001),
B- Mother's Delight Orange-fleshed Sweet Potato(UMUSP002),
C- CFSP- Cream-fleshed Sweet Potato.

2. Materials and methods

2.1. Materials

Mother's delight orange-fleshed sweet potato (UMUSP002) and King-J orange-fleshed sweet potato (UMUSP001) were obtained from an International Potato Center (CIP) demonstration farm at Iloko – Ijesa, Osun State, Nigeria. Cream-fleshed sweet potato (Hannah variety) was obtained from "*Shasha*" market in Akure, Ondo State, Nigeria.

2.2. Methods

2.2.1. Sample preparations

2.2.1.1. Preparation of sweet potato flour. The tubers of sweet potato varieties (OFSP and CFSP) were processed into flour by the method described by Oloniyo et al. (2020).

2.3. Sample analysis

2.3.1. Proximate composition

The proximate (moisture, crude protein, crude fat, crude fibers, and crude ash) composition of sweet potato flour were determined according to the method described by AOAC (2010). Carbohydrates were calculated by difference. The caloric value was calculated by Atwater factor method as described by Osborne and Voogt (1978).

2.3.2. Dry matter (DM) content

The dry matter was calculated with the formulas described by Routa et al. (2018) as shown below:

$$\mathrm{DMwb} = TWb - \left(\frac{MCb}{100} * TWb\right) \quad (1)$$

$$\mathrm{DMwc} = TWc - \left(\frac{MCc}{100} * TWc\right) \quad (2)$$

$$DM = DMwb - DMwc \quad (3)$$

Thus: Subtracting equation two (2) from one (1), this resulted in equation three (3) as shown above and equation three (3) was used to calculate the dry matter of the sample. Where:

DMW_b - initial weight of sample, DMW_c - final weight of sample, DM - dry matter
TW_b - initial weight of the sample, TW_c - final weight of the sample, MC_b - initial moisture content of the sample and MC_c - final moisture content of the sample

2.3.3. Beta (β)-carotene content

Carotenoid content of sweet potato flour was determined using organic solvents (acetone-petroleum ether) for the extraction followed by spectrophotometric method of analysis, as described by Rodriguez-Amaya and Kimura (2004).

2.4. Mineral contents

The contents of Calcium (Ca), Iron (Fe), Sodium (Na), Magnesium (Mg), Zinc (Zn), Potassium (K), and Phosphorous (P) were determined as described by Association of Official Analytical Chemists (2010). The single official AOAC multi-element method (AOAC 968.08) and the atomic absorption spectroscopy method were used for determining Ca, Fe, and Zn content, the AOAC official method 964.04 was used to determine the P content. Na and K content was determination using a flame photometer.

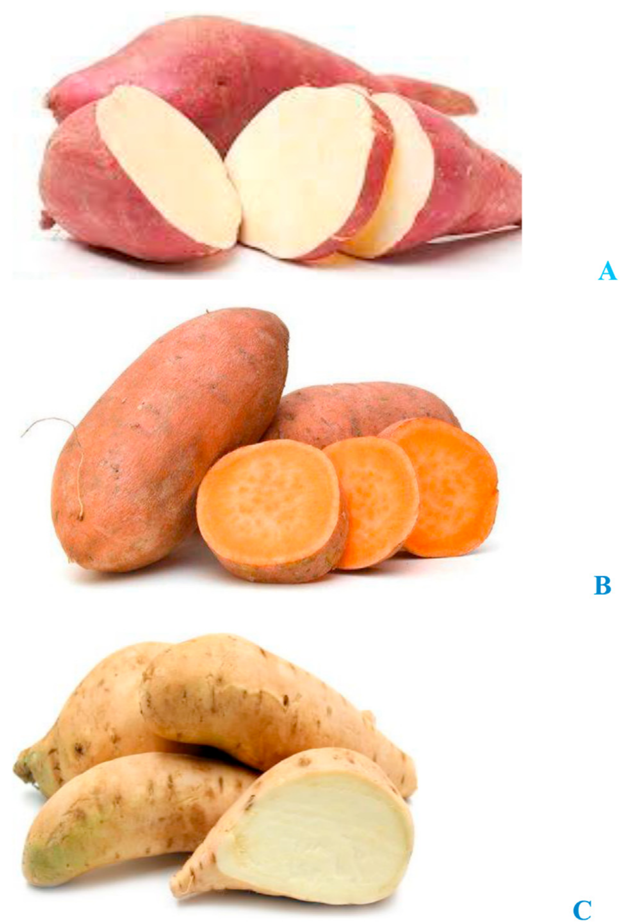

Figure 1. Pictures of sweet potato varieties used. (A) KJP- King J Orange-fleshed Sweet Potato (UMUSP001), (B) MDP- Mother's Delight Orange-fleshed Sweet Potato (UMUSP002), (C) CFSP- Cream-fleshed Sweet Potato.

2.5. Anti-nutritional composition

The phytate content of the sweet potato flour was determined using the indirect colorimetric method as described by Wheeler and Ferrel (1971). The oxalate content of the sweet potato flour was determined as described by AOAC (2010) method. The tannin content of the sweet potato flour was determined as described by Joslyn (1970).

2.6. Phytate mineral molar ratio

The moles of phytate and minerals were obtained by dividing the weight of phytate with minerals of each mineral molecular weight as described by Norhaizan and Nor Faizadatul (2009). The phytate mineral molar ratio was obtained by dividing the moles of phytate with the moles of each mineral as shown in the mathematical expression below:

$$\text{Molar ratio (Mr)} = \frac{\text{Pa/MwPa}}{\text{Min/Mwin}} \tag{4}$$

Eq. (4) was used to calculate the molar ratio.
Where: Pa = Calculated phytate content

Mwpa = Molecular weight of Pa = 660
Min = Mineral content obtained for each minerals (i.e Zn, Ca and Fe)
Mwin = mineral molecular weight (Zn = 65, Fe = 56, Ca = 40 g/mol).

2.7. Sample extraction for antioxidant assay of sweet potato flour

Sweet potato flour extracts were prepared with acidified methanol containing 1% hydrogen chloride (HCl) in methanol as described by Obafaye and Omoba (2018).

2.7.1. Total phenolic and total flavonoid content of flour

Total phenolic content of the sweet potato flour extracts was determined by the method described by Singleton et al. (1999), its concentration were calculated and expressed as Gallic Acid Equivalent (GAE) of the sample. Total flavonoid content of the sweet potato flour was determined using the method described by Meda et al. (2005), its concentration were calculated and expressed as mg quercetin equivalents per gram (QE)/g of the sample.

2.7.2. Ferric reducing antioxidant power (FRAP) of flour

FRAP of the sweet potato flour extract was determined with the method described by Oyaizu (1986) and its content was calculated and expressed as mg ascorbic acid equivalent/g (mgAEE/g) of the sample.

2.7.3. Total antioxidant capacity (TAC) of flour

TAC of the sweet potato flour extract was determined by the method based on the reduction of Molybdenum (VI) to Molybdenum (V) by the flour extract and the subsequent formation of a green Phosphate/Molybdenum (V) complex at an acidic pH as described by Prieto et al. (1999) and its content was calculated and expressed as μmol AAE.

2.8. Statistical analysis

The data were generated in triplicates; it was analyzed using Statistical Package for Social Sciences (SPSS) Version 21. The significant differences between the means were separated using Duncan Multiple Range Test (DMRT) at 95% confidence level ($P \leq 0.05$). The proximate and mineral values were also compared with the international permissible limits of FAO (2010) and USDA (2010).

3. Results and discussion

3.1. Proximate composition of sweet potato flours

The results of the proximate composition, dry matter and β-carotene content of sweet potato flours are presented in Table 2. Moisture contents ranged from 5.19 to 6.12% with CFSP having the highest moisture content (6.12%). Moisture content of OFSP varieties were significantly ($p \leq 0.05$) different from each other. The moisture content values obtained were lower than the recommended moisture content (10%) for storage stability (Iwe et al. 2017, FAO (2010)) thus, the sweet potato flour will have a longer shelf life if properly stored under a good condition.

Crude ash contents ranged from 4.60 to 7.20%, the highest ash content was observed in KJP, this indicates that KJP could be a rich source of mineral salts. Ash is an inorganic compounds present in a food which helps in the breaking down of some organic compounds such as protein, fat and carbohydrates (Iwe et al., 2017). Crude fat contents ranged from 1.53 to 1.84%, sweet potato are known for their low-fat content (Alam et al., 2016). It was observed that fat contents of MDP and KJP were significantly higher than CFSP. The observed difference among the three varieties could be attributed to genetic variation. The low fat content obtained in this study is in agreement with the findings of Alam et al. (2016) that sweet potato is low in fat.

Crude protein content of the varieties of sweet potato flour ranged from 2.14 to 2.86%, this suggests that sweet potato is a poor source of protein. This agrees with the report of Dako et al. (2016) that sweet potato cultivars has low protein content values ranged from 2.48 to 6.50 g/100g. Both OFSP varieties (MDP and KJP) had the highest contents of protein of 2.21 and 2.86% respectively when compared with CFSP (2.14%), this difference in protein might be attributed to genetic makeup of each variety.

Crude fibre contents ranged between 6.33 and 9.51%, this implies that sweet potato could be utilized as a good source of dietary fibre in a food system. KJP had the highest fibre content (9.51%). The carbohydrate content ranged between 73.47 and 78.61%, the high carbohydrate content observed implies that sweet potato was a rich source of carbohydrate. Carbohydrate is needed by infants for energy for the rigorous crawling and other activities for their growth and development. Energy value ranged from 333.00 to 339.00 kcal/100g, MDP had the highest energy value of 339.00 kcal/100g.

The dry matter (DM) content ranged from 23 to 34%, KJP exhibited the highest dry matter content (34%). DM content is an important factor to be considered in both raw and processed foods as it relates to good cooking qualities and extended storage ability (Eleazu and Ironua 2015). KJP therefore could be recommended for flour-producing industries for the production of flour products such as composite flour, baking flour and weaning flour. High dry matter flour could be recommended for the production of weaning and confectionary products.

The β carotene value ranged from 3.63 to 18.83 mg/100g. The highest β carotene content was observed in MDP (18.83 mg/100g), followed by KJP (4.49 mg/100g) while the least was observed in CFSP (3.63 mg/100g). This agrees with the report of previous researchers that OFSP variety of sweet potato has higher content of carotenoids (Alam et al., 2016; Tumuhimbise et al., 2019). The higher content observed in MDP could be attributed to the deep orange colouration observed in both its skin and flesh of OFSP (Adebisi et al., 2015). β-carotene is a red-yellow pigment in plants, it is an antioxidants that protect the cells from the production of free radicals which damages the cells (Ramya and Patel, 2019). Beta (β) carotenes are micronutrient in foods, when consumed it is converted to rhodopsin and retinal, a visual pigment and precursor of retinoid acid, which regulates growth and visual development in the body (Fraser and Bramley, 2004).

Table 2. Proximate composition of sweet potato flours (*Dry weight basis*).

Nutrient composition (%)	MDP	KJP	CFSP	FAO (2010) and USDA (2010) Limits (%)
Moisture	5.21 ± 0.2[b]	5.19 ± 0.1[c]	6.12 ± 0.3[a]	<10
Ash	5.80 ± 0.1[b]	7.20 ± 0.1[a]	4.60 ± 0.6[c]	>3
Fat	1.84 ± 0.1[a]	1.77 ± 0.3[b]	1.53 ± 0.1[c]	10–15
Protein	2.21 ± 0.2[b]	2.86 ± 0.2[a]	2.14 ± 0.1[c]	15-28
Fibre	6.33 ± 0.1[c]	9.51 ± 0.2[a]	7.91 ± 0.2[b]	<3
Carbohydrate	78.61 ± 0.2[a]	73.47 ± 0.3[c]	77.70 ± 0.3[b]	>64
Energy (Kcal)	339.00 ± 0.3[a]	321.00 ± 1.2[c]	333.00 ± 1.0[b]	>344
Dry mater	23.00 ± 0.1[c]	34.00 ± 0.1[a]	29.00 ± 0.2[b]	
β-Carotene (mg/100g)	18.83 ± 0.2[a]	4.49 ± 0.3[b]	3.63 ± 0.1[c]	

Values are averages of triplicate readings (mean ± standard deviation). Means within a row followed by different superscripts letter(s) are significantly different ($p \leq 0.05$).
Key:
MDP- Mother's Delight Orange-fleshed Sweet Potato(UMUSP002),
KJP- King J Orange-fleshed Sweet Potato (UMUSP001),
CFSP- Cream-fleshed Sweet Potato.

3.2. Mineral composition of sweet potato flours

The mineral compositions of sweet potato flours are presented in Table 3. KJP had the highest value in calcium (50.6 mg/100g), magnesium (148.2 mg/100g), potassium (2350 mg/100g) and sodium (10.7 mg/100g) while MDP had the highest value in zinc (4.4 mg/100g) and phosphorous (402.5 mg/100g), MDP and CFSP has the same Iron value of 8.8 mg/100g. CFSP had the least value of all the minerals except for potassium with value (1805 mg/100g) higher than MDP (1226.5 mg/100g). The results obtained in this study are similar to the report of Tiruneh et al. (2018); Dako et al. (2016) for orange-fleshed sweet potato and sweet potato varieties respectively. Cadmium (Cd), chronium (Cr) and lead (Pb) were not detected in the sample which implies that the flour samples are safe for consumption.

Minerals are desirable in human body for cellular activity of enzyme, nerve responses muscle contraction and blood clotting (Gupta, 2019). Foods rich in calcium are vital for bone health and development in infants (Loughrill et al., 2017). Iron is an important component of hemoglobin (substance in the red blood cells that carries oxygen from the lungs to other parts of the body). Iron is a significant constituent of blood and enzymes involved for electron transfer, its deficiency can results in tiredness, weakness, anemia (McLaren, 2019). Zinc is a desirable mineral by pregnant women for safe baby delivery; it is use for body's defensive (immune) system, protein and nucleic acid synthesis, carbohydrate absorption and normal body growth. Potassium is important in regulating the body fluid balance required for the transmission of nerves impulse in the body (Zoroddu et al., 2019). High potassium intake is associated with lowering blood pressure and the effect of increasing potassium as an additive is to lower sodium intake. Diets low in sodium but high in potassium, calcium and magnesium had been associated to lower the rate of cardiovascular diseases (Parpia et al., 2018).

In this study, the values obtained for Na/K in the three varieties of sweet potato examined are less than one (1). This implies that sweet potato flour can be used as a therapeutic diet for patient with chronic and degenerated disease such high blood pressure, hypertension, cardiovascular disease, obesity and for children with immature heart (Ijarotimi and Keshinro 2012). Also, mineral ratio plays an important role in proper

Table 3. Mineral composition parameters of sweet potato flours (*Dry weight basis*).

Elements (mg/100g)	MDP	KJP	CFSP	FAO (2010) and USDA (2010) Limits (mg/day)
Calcium (Ca)	45.5 ± 0.31[b]	50.6 ± 0.22[a]	33.1 ± 0.17[c]	19-881
Magnesium (Mg)	125.7 ± 0.23[b]	148.2 ± 0.10[a]	124.0 ± 0.91[c]	4.5-452
Potassium (K)	1226.5 ± 0.11[c]	2350.0 ± 0.42[a]	1805.0 ± 0.66[b]	19-502
Sodium (Na)	458.0 ± 0.32[b]	615.5 ± 0.12[a]	385.0 ± 0.43[c]	30-134
Iron (Fe)	8.8 ± 0.53[b]	10.7 ± 0.23[a]	8.8 ± 0.11[b]	1-5.6
Zinc (Zn)	4.4 ± 0.10[a]	4.1 ± 0.09[b]	3.5 ± 0.11[c]	0.23-2.1
Phosphorous (P)	402.5 ± 0.21[a]	313.5 ± 0.11[b]	285.0 ± 0.32[c]	
Cadmium (Cd)	ND	ND	ND	
Nickel (Ni)	0.02 ± 0.00[b]	0.01 ± 0.00[a]	0.01 ± 0.00[a]	
Chromium (Cr)	ND	ND	ND	
Copper (Cu)	0.01 ± 0.00[a]	0.01 ± 0.00[a]	0.01 ± 0.00[a]	
Lead (Pb)	ND	ND	ND	
Na/K	0.37	0.26	0.21	<1

Values are averages of triplicate readings (mean ± standard deviation). Means within a row followed by different superscripts letter(s) are significantly different ($p \leq 0.05$).
Key:
MDP- Mother's Delight Orange-fleshed Sweet Potato (UMUSP002).
KJP- King J Orange-fleshed Sweet Potato (UMUSP001).
CFSP- Cream-fleshed Sweet Potato.
ND- Not detectable.
FDA- Food and Drug Administration.

Table 4. Anti nutritional properties and molar ratios of sweet potato flours (*Dry weight basis*).

	Antinutrients	MDP	KJP	CFSP	Standard
Antinutrients	Phytate (mg/100g)	40.36 ± 4.4[a]	36.03 ± 2.4[b]	34.26 ± 3.2[c]	<450
	Oxalate (mg/100g)	0.22 ± 0.1[b]	0.30 ± 0.0[a]	0.10 ± 0.0[c]	<50
	Tannin (mg/100g)	4.01 ± 0.1[b]	5.41 ± 0.1[a]	3.01 ± 0.3[c]	
Molar Ratio	Phy:Ca	0.07	0.04	0.13	>1.56
	Phy:Fe	0.39	0.29	0.33	>14
	Phy:Zn	0.96	0.87	0.80	>10

Values are averages of triplicate readings (mean ± standard deviation). Means followed by different superscripts within the row indicate significant differences ($p \leq 0.05$)
Key:
MDP - Mother's Delight Orange-fleshed Sweet Potato (UMUSP002).
KJP - King J Orange-fleshed Sweet Potato (UMUSP001).
CFSP- Cream-fleshed Sweet Potato.
Phy- Phytate.
Ca- Calcium.
Fe- Iron.
Zn- Zinc.
Critical limit source: Haile and Getahun (2018).

growth and development of the skeletal system (Muszyński et al. 2018). Inadequate intake of minerals does lead to severe malnutrition, increased disease condition and mental impairment. Consumption of high Na and low K foods can increase the risk of high blood pressure, heart diseases and stroke while low consumption of Na and high K foods could help to control hypertension and lowers the risk of cardiovascular diseases and death.

3.3. Antinutritional properties and molar ratio of sweet potato flours

The anti-nutritional factors of sweet potato flours are presented in Table 4. Statistically, there were significant ($p \leq 0.05$) difference in the varieties of sweet potato flour examined. MDP had the highest phytate value (40.36 mg/100g) followed by KJP (36.03mg/100g) and the least value was observed in CFSP (34.26 mg/100g). The variations observed in values among the varieties might be attributed to the cultivars differences. The values obtained in this study were lower compared to the phytate values reported by Dako et al. (2016) for peeled and unpeeled OFSP (77.75 and 95.15 mg/100g, respectively). Phytate produces phytic acid which is a major phosphorous storage component that chelate metalic ion such as Zinc, Calcium and Iron, thereby reducing their bioavailability (Connorton et al. 2017). Oxalate content of the three varieties of sweet potato ranged from 0.10 to 0.30 mg/100g. KJP had the highest oxalate value of 0.30 mg/100g followed by MDP with 0.22 mg/100g and the least value is shown in CFSP (0.10 mg/100g). The observation among the varieties might be attributed to the cultivar differences. The oxalate values obtained in this study were lower compared to the values (5.71mg/100g) reported by Dako et al. (2016) for unpeeled OFSP. Oxalate has been reported by Noonan and Savage (1999) to have a harmful effect on human nutrition and health because it has the ability to reduce calcium absorption in the form of calcium oxalate in the blood and thus aid the formation of a kidney stone.

Tannin values of sweet potato ranged from 3.01 to 5.41 mg/100g. The highest tannin (5.41 mg/100g) followed by MDP (4.01mg/100g) and the least value was observed in CFSP (3.01 mg/100g). The results obtained in this study were lower than values reported by Tiruneh et al.

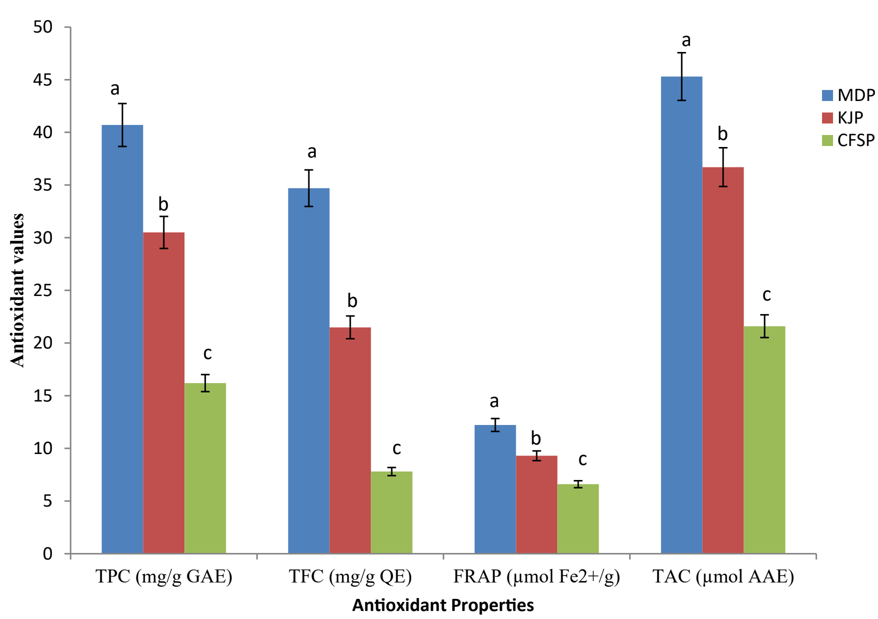

Figure 2. Total phenolic content (TPC), total flavonoid content (TFC), ferric reducing antioxidant power (FRAP) and total antioxidant capacity (TAC) of flours from OFSP (MDP and KJP) and cream-fleshed sweet potato (CFSP). Key: MDP- Mother's Delight Orange-fleshed Sweet Potato (UMUSP002), KJP- King J Orange-fleshed Sweet Potato (UMUSP001), CFSP- Cream-fleshed Sweet Potato, GAE - Gallic acid equivalent, QE- Quercetin, Fe^{2+}- Iron II, AAE - Ascorbic acid equivalents.

(2018) who reported that the tannin values for Kulfo & Tulla (varieties of OFSP in Ethiopia) are 89.36 and 40.02 mg/100g respectively. High values of anti-nutrient (phytate, oxalate and tannin) in food are undesirable because they form complexes with minerals and proteins resulting in its unavailable to the body system (Gibson et al. 2010; Tiruneh et al., 2018) thereby leading to carcinogenesis, shock and renal damage (Onwuka, 2005). Anti-nutritional factors are substances that destructively affect the nutritional composition of a food thereby reducing both the mineral and protein bioavailability, digestion and its utilizations in the body (Gibson et al., 2010; Tiruneh et al., 2018).

Phy: Ca ranged from 0.04 to 0.13, Phy: Fe ranged from 0.23 to 0.39 and Phy: Zn ranged from 0.80 to 0.96. It was observed that all the molar ratios were below the critical limits (Phy: Ca $>$ 1.56, Phy: Fe $>$ 14 and Phy: Zn $>$ 10) as reported by Haile and Getahun (2018). This implies that the bioavailabilities of Ca, Fe & Zn are not inhibited by the concentration of phytate in the varieties of sweet potato examined. This was an indication that all the minerals (Ca, Fe & Zn) in the sweet potato flour will be adequately absorbed by the body when consumed. The molar ratio between phytate and divalent cations (Ca, Fe & Zn) indicates the impact of phytate on the bioavailability (ability of the body to absorb and digest minerals in a food after consumption) of dietary minerals and the absorption of these cations were not adversely affected by the amount of phytate in the varieties of sweet potato examined (Tiruneh et al., 2018).

3.4. Total phenolic content (TPC), total flavonoid content (TFC) and antioxidant properties of sweet potato flours

Total phenolic content (TPC), total flavonoid content (TFC) and antioxidant properties of sweet potato flours are shown in Figure 2. Total phenolic content (TPC) of flours ranged from 16.20 to 40.70 mg/g GAE. The highest value of TPC was observed in MDP (40.70 mg/g GAE) followed by KJP (30.33 mg/g GAE) while the least was observed in CFSP (16.20 mg/g GAE). Total flavonoid content (TFC) of flours ranged from 7.80 to 34.70 mg/g QE. The highest value of TFC was observed in MDP (34.70 mg/g QE) followed by KJP (17.90 mg/g QE) while the least was observed in CFSP (7.8 mg/g QE). The ferric reducing antioxidant properties (FRAP) of flours ranged from 6.6 to 12.22 μmol Fe^{2+}/g. The highest value of FRAP was observed in MDP (12.22 μmol Fe^{2+}/g) followed by KJP (7.19 μmol Fe^{2+}/g) while the least value was observed in CFSP (6.6 μmol Fe^{2+}/g). Total antioxidant capacity (TAC) of flour ranged from 21.60 to 45.30 μmol AAE. The highest value of TAC was observed in MDP (45.30 μmol AAE) followed by KJP (36.40 μmol AAE) while the least value was observed in CFSP (21.60 μmol AAE).

It was observed that MDP had the highest value of all the antioxidant properties determined followed by KJP and the least value was observed in CFSP. The higher antioxidant properties observed in MDP might be attributed to the higher beta carotene content as observed in Table 2 that MDP flour has high beta carotene compared to other variety considered. Awuni et al. (2018) reported that beta (β) carotenes are good sources of antioxidant molecules that are available in plants. Carotene is natural plant produced yellow pigment that exists in several forms: alpha (α), beta (β) and gamma (γ). It is pro-vitamins that may be converted into vitamin A in the body. Antioxidants are capable of scavenging free radicals, chelate metals catalysts, reduce α-tocopherol radicals, activate antioxidant enzymes and inhibit oxidases (Omoba et al., 2015).

4. Conclusion

This study established that the minerals values obtained from OFSP (Mother's delight and King J) are higher than that of CFSP (Hannah Variety), and they are both safe for consumption. Sodium/Potassium ratio (Na/K) of the OFSP and CFSP examined are less than one (1), therefore this could be used for therapeutic diet for patient with chronic and degenerated disease such as high blood pressure, hypertension, cardiovascular disease, obesity and children with embryonic heart. It was observed that KJP has the highest dry matter compared to other varieties and this could make KJP suitable for the production of baking products and weaning foods in flour mill industries. MDP showed higher antioxidant properties compared to the KJP and CFSP, thus; this will could make MDP suitable to combat micronutrient deficiency and food insecurity in Africa especially in Nigeria.

Declarations

Author contribution statement

Rebecca Olajumoke Oloniyo: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Olufunmilayo Sade Omoba, Olugbenga Olufemi Awolu: Conceived and designed the experiments; Wrote the paper.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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