Trop J Nat Prod Res, February 2024; 8(2):6100-6107 ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Original Research Article

Nutritional and Chemical Constituents of Different Cultivars of Sweet Potato (*Ipomoea batatas L.*) Grown in South Africa

Taiwo B. Ayeleso[1], Peluola O. Ayeni[2], Ademola O. Ayeleso[2,4], Khosi Ramachela[3] and Emmanuel Mukwevho[1]*

[1]*Department of Biochemistry, North West University, Private Bag X2046, Mmabatho 2735, South Africa*
[2]*Biochemistry Programme, Bowen University, P.M.B 284, Iwo, Osun State, Nigeria*
[3]*Department of Crop Science, North-West University, Private Bag X2046, Mmabatho 2735, South Africa;*
[4]*Department of Life and Consumer Sciences, University of South Africa, Florida Park 1709, Roodeport, South Africa*

ARTICLE INFO

Article history:
Received 26 September 2023
Revised 18 November 2023
Accepted 12 February2024
Published online 01 March 2024

ABSTRACT

Sweet potato is one of the most important crops being promoted for food security and nutrition in South Africa. This study investigated the nutritional and chemical compositions of four white-fleshed (Blesbok, Ndou, Monate, and Mvuvhelo) and three orange-fleshed (Bophelo, Impilo, and 199062.1) cultivars. The protein, ash, and crude fibre contents were analysed using standard AOAC procedures. The detection of fatty acids, sugar, and metabolites was carried out using Gas Chromatography–Mass Spectrometry (GC-MS). Carbohydrate and energy values were determined using standard methods. The results showed that Bophelo had the highest protein content (12.00%), with Blesbok having the lowest protein content (4.56%). The study also revealed that Impilo had the highest fibre (7.11%) and total sugar (22.21 %) contents. The highest ash content was found in 199062.1 (5.81 %) and the lowest was observed in Monate (4.50 %). Bophelo had the highest total fat content (0.650 %), with saturated, mono-saturated, and poly-saturated fats of 0.270 %, 0.050 %, and 0.270 %, respectively, while the lowest fat content was observed in Impilo (0.380 %), with saturated, mono-saturated, and poly-saturated fats of 0.225 %, 0.020 % and 0.135 %, respectively. The highest total carbohydrate content was found in Blesbok (76.72 %). Different fatty acids, including palmitic acid (C16), stearic acid (C18), arachidic acid (C20), oleic acid (C18:1), and linoleic acid (C18:2) were also found in the sweet potato cultivars. This study demonstrated significant variations in the chemical composition of the cultivars, providing valuable insights for informed dietary decisions on consumption.

***Keywords*:** Sweet potato, Blesbok, Ndou, Monate, Mvuvhelo, Bophelo, Impilo,

Introduction

Malnutrition exacerbates human suffering and has a profound impact on the socio-economic development of a nation.[1] An important approach against malnutrition is the promotion of underutilized traditional crops for food security and nutrition.[2, 3] There is a need for increased efforts to boost the supply of healthy food at a rate that matches or exceeds the population growth, and failure to promptly address this need may lead to widespread malnutrition.[4] Starchy root and tuber crops are next in terms of importance to cereals as global sources of carbohydrates, and they are vital source of animal feed and processed products for human consumption and industrial use.[5, 6] Sweet potato (*Ipomoea batatas*) is an important crop in different areas of the world, being grown in more than 100 countries.[6] The crop is produced mainly in Asia, which accounts for up to 76.1% of world production in 2013, followed by the African continent (19.5%).[7,8] It is rated as the seventh most important food crop across the world.[9] It is a tuberous-rooted perennial plant belonging to the Convolvulaceae or morning glory family.[10]

*Corresponding author. E mail: Emmanuel.mukwevho@nwu.ac.za
Tel: +27183892854

Citation: Ayeleso TB, Ayeni PO, Ayeleso AA, Ramachela K, Mukwevho E. Nutritional and Chemical Constituents of Different Cultivars of Sweet Potato (*Ipomoea batatas L.*) Grown in South Africa. Trop J Nat Prod Res. 2024; 8(2):6100-6107. http://www.doi.org/10.26538/tjnpr/v8i2.7

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria.

Maximum yields of sweet potato are obtained on a well-drained, sandy or silt loam soil. They require both warm days and nights for optimum growth and root development.[11] Sweet potato is one of the food security crops that can help in the alleviation of poverty among rural dwellers through better processing methods and food diversification.[12] Sweet potato, when compared with the other tubers, contains an average amount of proteins and carbohydrates, mainly starch, with some free sugars that give the tuber its sweet taste.[13]

It has been reported that phytochemicals in sweet potato possess multifaceted properties, such as anti-oxidant, anti-mutagenic, anti-inflammatory, antimicrobial and anti-carcinogenesis effects.[11, 14] In this study, we collected seven different sweet potato cultivars grown under the same conditions in North-West Province of South Africa and carried out a comparative analysis of their nutrient and chemical compositions. This work will provide an opportunity for the identification of sweet potato cultivars that can provide healthier diet and food security for South Africans and the world at large. Our findings will facilitate the breeding of sweet potato cultivars with high nutritional qualities, further increasing food security and potential industrial use of the cultivars.

Materials and Methods

Preparation of plant materials

Sweet potato cultivars (Table 1) were obtained from the Agricultural Research Council (ARC), South Africa through the Department of Crop Science, North-West University, Mafikeng campus, South Africa (GPS coordinates: S25º49´44´). The tubers of each cultivar were collected fresh from the university farm. They were rinsed and washed thoroughly with running water. Next, they were cut into thin chips before being air dried in the laboratory. Air-dried samples were ground into fine powder

and packed in an air tight container. They were labeled accordingly and stored at 4ºC for further use.

Determination of Protein Content
Samples were analysed using the TruSpec-N Leco Protein Analyser according to the manufacturer`s instruction manual. They were homogenised prior to analysis by using a blender. The regulator pressures on each of the gases were as follows: oxygen and helium were at 241.3 kPa and compressed/pneumatic air was at 275.8 kPa. Leco TruSpec application was activated on the computer screen and the temperatures of the Combustion Furnace and Afterburner Temperatures were set to 950ºC and 850ºC, respectively. Approximately 100200 mg of the sample was weighed into tin foil. Five blanks, EDTA standard, ProNutro (original) control, and samples in duplicate were analysed. Controls were run after every ten sample runs. The percentage nitrogen was calculated by the comparison of peak areas of nitrogen in samples with those of standards. The percentage protein content was calculated as described below:[15]

$$\%\ \mathrm{Protein} = \%\ \mathrm{Nitrogen} \times \mathrm{Protein\ factor}\ (6.25) \qquad (1)$$

Determination of Fiber Content
Fibre content was determined by using the method of Association of Official Analytical chemists (AOAC).[16] A homogenous sample (1 g) was quantitatively weighed into beakers. 2-(N-morpholino) ethanesulfonic acid (MES) - Tris buffer solution (40 mL) was added to each beaker. A heat-stable amylase solution (50 µL) was added while stirring at low speed, and the beaker was covered with an aluminium foil. The samples were then placed in a shaking water bath at 95-100ºC for 35 minutes with continuous agitation. They were removed from hot water and cooled to 60ºC. A protease solution (100 µL) was added to each sample, followed by incubation at 60ºC with continuous agitation for 30 min. After 30 minutes, 0.561 N HCl solution (5 mL) was dispensed into the sample while stirring. The pH was adjusted to 4.1 – 4.8 with additional 5% NaOH solution or 5% HCl solution, as necessary. Next, amyloglucosidase solution (200 µl) was added while stirring on a magnetic stirrer, followed by further incubation in shaking water bath at 60ºC for 30 min. To each sample, 225 ml 95% EtOH preheated to 60ºC was added to allow precipitation to form at room temp for 1 hr. The precipitated enzyme digest was filtered through a weighed crucible with celite. The samples were quantitatively transferred by rinsing with 78% ethanol, 95% ethanol, and acetone. The crucibles containing residues were dried overnight for 5 hrs at 105ºC in air convection oven. The crucibles were cooled in a desiccator and weighed to obtain the residue weight.

The percentage of fibre content was calculated using the following formula:

$$\mathrm{Dietary\ fibre}(\%) = \frac{\frac{R1+R2}{2} - \rho - A - B}{\frac{M1+M2}{2}} \times 100, \qquad (2)$$

where:
R1 = residue weight 1 from m1; R2 = residue weight 2 from m2
M1 = sample weight 1; M2 = sample weight 2
A = ash weight from R1, p = protein weight from R2
B = blank

$$B = \frac{BR1 + BR2}{2} - BP - BA, \qquad (3)$$

where: BR = blank residue
BP = blank protein BR1
BA = blank ash from BR2

Determination of Ash Content
Ash content was determined by using the method of AOAC.[17] In triplicates, 5 g of the samples were weighed into an empty pre-weighed crucible and carefully charred over an open flame in the fume cupboard until the samples were black and smoke free. The muffle furnace was pre-heated to 500°C before putting the samples and ashing was done overnight. The furnace was turned off to allow cooling before the removal of samples. The samples were desiccated prior to weighing, and the ash content was calculated as described below:

$$\%\ \mathrm{Ash} = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100, \qquad (4)$$

where

W_1 = Weight of crucible soon after reaching room temperature (W_1).

W_2 = Weight of crucible +sample before ashing.

W_3 = Weight of crucible +sample after ashing

Determination of Fat Content
The determination of fatty acid content was carried out using the modified method of AOAC.[18] After homogenizing the samples, the sample masses of about 1 g were weighed into digestion tubes and 100 mg pyrogallic acid was added, followed by 2 mL of undecanoic acid (internal standard) solution, 2 mL of ethanol, and 10 mL of 32% hydrochloric acid. The tubes were then placed in the water bath at 75°C with gentle shaking for 40 min. The fatty acids were extracted with diethyl ether and petroleum ether. The organic phase was dried and the residue was methylated using 2 mL of sulphuric acid/methanol reagent and 1 mL of toluene at 100°C for 5 min. After cooling to room temperature, 5 mL of distilled water and 1 mL of hexane were added and the hexane solution was then dried with anhydrous sodium sulphate. Next, the residue was transferred into a vial for gas chromatographic analysis. FAMEs were then quantitatively measured by using GCFID. Fatty acids were identified by comparing their retention times to those of the standards.

Determination of Sugar Content (mono and disaccharides)
The determination of sugar levels was carried out using the method of AOAC.[19] Sugar was extracted from the sample by weighing 5 g of grounded sample (W1) into a 250 mL beaker and 100 mL of 50% ethanol was added into the beaker. The weight of the beaker with the content was measured (W2), and the beaker was placed in a water bath at 85°C for 25 minutes, with stirring at intervals of 10 min to break-up or dissolve the sample. The sample solution was cooled at room temperature, followed by the addition of 95 % ethanol. The sample was then filtered through a 0.45-µm nylon syringe filter into a vial, and the filtrate was injected into an HPLC (Agilent1200LC system, Agilent Technologies, Santa Clara, CA, USA) equipped with a RI detector. The mobile phase was a mixture of acetonitrile and water (80:20, v/v) and the flow rate was 1.5 mL/min.

Determination of Carbohydrate Content and energy level
The carbohydrate contents and energy level were determined by using the formulas:

$$\%\ \mathrm{Carbonhydrate} = 100 - (\%\ \mathrm{moisture} + \%\ \mathrm{ash} + \%\ \mathrm{crude\ fibre} + \%\ \mathrm{crude\ protein} + \%\ \mathrm{fat}) \qquad (5)$$

$$\mathrm{Energy\ (kj/100g)} = 37(\%\mathrm{fat}) + 17(\%\mathrm{Protein} + \%\mathrm{Carbonhydrate}) + 8(\%\ \mathrm{Total\ dietary\ fibre}) \qquad (6)$$

Metabolites detection with GCMS
Preparation of crude aqueous (AQ) and aqueous/methanolic (1:1) (AQ-ME) extracts of the samples for the detection of metabolites were done by soaking 5 g of the powder in 100ml of the respective solvents for 24 hours at room temperature with constant shaking. Extracts were recovered through lyophilization and evaporation using a freeze dryer (Alpha 1-4 LSC Plus) and a rotary evaporator (RE-52A), respectively. Dried extracts were stored in the dark at -20ºC. The aqueous and aqueous-methanol extracts of the samples were re-dissolved at a

concentration of 10 mg/mL in vials, and 50 ppm 3-Phenylbutyric acid was added to each sample as internal standard. The samples were then dried under liquid nitrogen in a solvent evaporator machine. Derivatization was done by the addition of 50 µL of oximation reagent (20mg/ml methoxyamine in pyridine) to the dried samples. The mixtures were vortexed for 1 minute to dissolve the dried compounds. Silylation was carried out by adding 50 µL of NO-Bis(trimethylsilyl)trifluoroacetamide (BSTFA) containing 1% Trimethylsilyl chloride (TMCS) to the oximated samples. Each sample was then transferred into micro-vials and transferred to the GC-MS machine for analysis.

Statistical analysis

Statistical analysis was performed with one-way analysis of variance (ANOVA) using Graph Prism 6, and comparisons were made by utilizing the Tukeys range test. Differences were considered significant at $p<0.05$.

Table 1: List of selected South African grown sweet potato cultivars

Cultivars	Skin colour	Flesh colour
Blesbok	Purple	White
Bophelo	orange	Dark orange
Ndou	Cream	Cream
Monate	Cream	Cream
Mvuvhelo	Cream	Cream
Impilo	deep orange	Light orange
199062-1	Cream	Light orange

Results and Discussion

Total protein content

As shown in Figure 1, Bophelo had the highest protein content (12.00 %), followed by 199062.1 (11.25 %). The protein contents of the other tubers were 4.56 %, 5.69 %, 6.31 %, 6.38 %, and 5.19 % for Blesbok, Ndou, Monate, Mvuvhelo, and Impilo, respectively. The total protein content of Bophelo was significantly higher than those of the other cultivars at $p<0.05$.

Proteins are vital macronutrients in food that provide both essential and nonessential amino acids that are required for growth, repair, and maintenance of tissues.[20] In this study, the protein contents of sweet potato cultivars used were higher than those of other cultivars from different geographical locations, ranging between 3.94 to 6.93 % in Nigeria[12], Bangladesh with values between 1.91-5.83 %.[21] Brazil with values that ranged between 4.80 to 5.82 %,[22] Rwanda with values ranging from 0.71 to 0.91 %[23] and 2.03 to 4.19 % in Benin.[24] The high levels of protein in these cultivars could be helpful in the reduction of kwashiorkor, a common protein-deficiency symptom in some parts of Africa.

Total fibre content

The results as shown in Figure 2 indicate that Impilo had the highest fibre content (7.11 %), followed by Mvuvhelo (6.66 %). The fibre contents of other tubers were 5.47 %, 5.69 %, 5.61 %, 5.60 %, and 5.95 % for Blesbok, Bophelo, Ndou, Monate, and 199062.1, respectively. The total fibre content of Impilo was significantly higher than those of Blesbok, Bophelo, Ndou, Monate, Mvuvhelo, and 199062.1 at $p<0.05$. The values obtained for fibre content in this study were higher than those reported in the study of Omodamiro *et al.*[12] , which ranged between 0.67 and 2.00 % in Nigeria, between 0.30 and 0.54 % in Bangladesh,[21] 2.57 % in Brazil,[22] between 2.56 and 4.70 % in Benin [24], and between 0.11 and 0.14 % in Rwanda.[23] High dietary fibre content is vital for improved digestibility, reduced blood cholesterol, and declined risk of large bowel cancers.[4] It has also been suggested that fibre can exert a wide range of benefits in areas such as bowel function, gut health, immunity, blood glucose control, and serum lipid levels.[25,26]

Total ash content

The results in Figure 3 show that 199062.1 had the highest ash content (5.81 %), followed by Blesbok (5.38 %). The ash contents of the other tubers were 5.03 %, 4.88 %, 4.50 %, 4.95 %, and 4.87 % for Bophelo, Ndou, Monate, Mvuvhelo, and Impilo, respectively. The total ash content of 199062.1 was significantly higher than those of Blesbok, Bophelo, Ndou, Monate, Mvuvhelo, and Impilo at $P<0.05$. The values obtained for ash content in this study were higher than those of Omidamiro *et al*.[12] and Anthony *et al*.[27] in Nigeria, which were in the range of 0.50 – 1.52 % and 2.27 – 3.10 %, respectively, as well as Alam et al.[21] in Bangladesh between 1.17 – 1.31 %,[25]. In Brazil between 2.04 – 3.80 %[22] and in Benin between 2.56 - 4.70 %.[24] The ash content is an indication of the presence of some mineral salts in the cultivars. Minerals are very essential and synergistically work with vitamins, enzymes, hormones, and other nutrient cofactors to effectively regulate many biological functions in the body.[28] Our findings indicate that the cultivars are good source of minerals, contributing to their potential in promoting overall health and well-being.

Total fat content and fatty acid composition

The result in Table 2 shows that Bophelo had the highest total fat content (0.650 %), with saturated, mono-saturated, and poly-saturated fats at 0.270 %, 0.050 %, and 0.270 %, respectively. The lowest total fat content was observed in Impilo (0.380 %), with saturated, mono-saturated, and poly-saturated fats at 0.225 %, 0.020 %, and 0.135 %, respectively. Analysis of the fatty acid composition indicated the presence of five fatty acids (palmittic acid (C16), stearic acid (C18), arachidic acid (C20), oleic acid (C18:1), and linolenic acid (C18:2) in the tubers of all the cultivars of sweet potato analysed in this study.

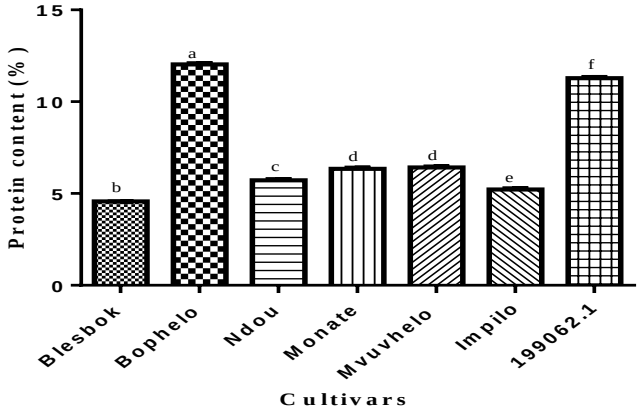

Figure 1: Protein contents of seven cultivars of sweet potato grown in South Africa

Same letters indicate non-significant difference, while different letters indicate significant difference at $P<0.05$.

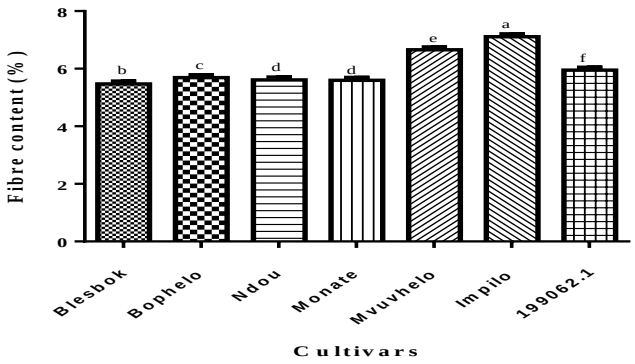

Figure 2: Fibre contents of seven cultivars of sweet potato grown in South Africa

Same letters indicate non-significant difference, while different letters indicate significant difference at $P<0.05$

The concentrations of C16 and C18:2 were more than those of C18, C20 and C18:2 in all the varieties of sweet potato. However, Monate had the highest C16 (0.257), followed by Bophelo (0.246 %) and then Blesbok (0.207 %), while the lowest concentration of C16 was in Impilo (0.157%). Bophelo had the highest C18:2 (0.282 %), followed by Blesbok (0.272 %) and then Monate (0.238 %), while the lowest C18:2 was in Impilo (0.120 %). The results also showed that the levels of total fat and polyunsaturated fat in Bophelo were significantly ($p<0.05$) higher than those of Ndou, Mvuvhelo, Impilo and 199062.1, but were not significantly different from those of Blesbok and Monate. The levels of saturated fat in all the cultivars were not significantly different across all the cultivars. However, there was a significant increase ($p<0.05$) in the level of monounsaturated fat in Blesbok, when compared with other cultivars. The level of C16 in Monate was significantly higher ($p<0.05$) than those of Ndou, Mvuvhelo, Impilo, and 199062.1 and not significantly different from those of Blesbok and Bophelo. Moreover, the level of C18 in Monate was significantly higher, compared with those in Bophelo, Ndou, Mvuvhelo, Impilo, and 199062.1 and not significantly different from that in Blesbok. The results also showed no significant difference in the level of C20 in Bophelo, compared with those in Ndou, Monate, and Mvuvhelo, while there was significant decrease ($p<0.05$) in Blesbok, Impilo, and 199062.1. There was a significant increase ($p<0.05$) in the level of C18:1 in Blesbok, compared with those in other cultivars. The level of C18:2 in Bophelo was significantly higher ($p<0.05$) than that in Ndou, Monate, Mvuvhelo, Impilo, and 199062.1 and were not significantly different from that in Monate. The values obtained for fat content in this study were lower than those reported by Omidamiro *et al.*[12] and Anthony *et al.*[27] for cultivars grown in Nigeria, which ranged from 1.02 to 1.72 % and 1.41 to 2.92 %, respectively. However, they were comparable with that reported in Brazil (0.39 %)[22] and higher than that reported in Bangladesh (0.11-0.14 %).[21] Reduced fat content in food is beneficial, particularly for individuals managing metabolic diseases, such as diabetes mellitus, cardiovascular diseases, and obesity. In this study, different fatty acids were found in the cultivars, including palmitic acid (C16, a saturated long chain fatty acid with sixteen carbon backbone), stearic acid (C18, a saturated fatty acid having 18-carbon chain), arachidic acid (C20, a saturated long-chain fatty acid with 20-carbon backbone), oleic acid (C18:1, a monounsaturated omega-9- fatty acid having 18-carbon chain with a single bond), and linoleic acid (C18:2, a polyunsaturated omega-6fatty acid having 18-carbon chain with two double bonds). Stearic acid has a neutral effect on total cholesterol, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol, unlike palmitic acid, which is noted for its hypercholesterolemic effect.[28] However, the adverse effects of palmitic acid are more pronounced when the concentration of linoleic acid in the diet is low.[28] Oleic acid has preventive effect against ulcerative colitis, and they have the ability to protect cells from free radical damage, decrease blood pressure, and enhance the fat burning process.[29]

Total sugar, carbohydrate, and energy values

Some starch in the sweet potato tubers can be converted into reducing sugars and subsequently into sucrose during storage, and hence, sucrose is the most abundant sugar in raw sweet potatoes with smaller amounts of glucose and fructose.[13,30,31]

Table 3 shows that Impilo had the highest total sugar content (22.21 %), containing fructose (3.99 %), glucose (3.71 %), sucrose (13.26 %), and maltose (1.25 %), followed by Blesbok. The total sugar, fructose, glucose, sucrose, and maltose contents of Blesbok were 21.94 %, 4.03 %, 3.80 %, 12.84 %, and 1.28 %, respectively. The sweet potato tuber with the lowest sugar content was Ndou, with total sugar, fructose, glucose, sucrose, and maltose contents of 15.84%, 1.75 %, 0.92 %, 11.86 %, and 1.31 %, respectively. The level of total sugar in Impilo was significantly higher than those in Bophelo, Ndou, Monate, Mvuvhelo, and 199062.1 and not significantly different from that in Blesbok. Moreover, the level of fructose in Blesbok was significantly higher ($p<0.05$) than those in Bophelo, Ndou, Mvuvhelo, and 199062.1 and not significantly different from those in Monate and Impilo, while the level of glucose in Blesbok was significantly higher ($p<0.05$) than those in Bophelo, Ndou, Monate, Mvuvhelo, and 19906.1 and not significantly different than that in Impilo. The results also showed significant decrease ($p<0.05$) in the level of sucrose in 199062.1, compared with those in other cultivars, while the level of maltose in Bophelo was not significantly different from those in other cultivars.

Table 2: Fat contents (%) of seven cultivars of sweet potato grown in South Africa

Cultivars	Saturated Fatty acids			Total Saturated Fat	Mono-unsaturated Fatty Acids	Poly-unsaturated Fatty acids	Total Fat (%)
	C16	C18	C20		C18:1	C18:2	
Blesbok	0.21 ± 0.01^{ab}	0.04 ± 0.00^{b}	0.04 ± 0.04^{b}	0.30 ± 0.01^{a}	0.05 ± 0.00^{a}	0.27 ± 0.01^{a}	0.60 ± 0.01^{a}
Bophelo	0.24 ± 0.00^{a}	0.04 ± 0.00^{b}	0.08 ± 0.00^{a}	0.34 ± 0.01^{a}	0.04 ± 0.00^{a}	0.28 ± 0.00^{a}	0.65 ± 0.01^{a}
Ndou	0.19 ± 0.02^{ab}	0.03 ± 0.00^{b}	0.06 ± 0.00^{a}	0.28 ± 0.03^{a}	0.02 ± 0.00^{b}	0.17 ± 0.00^{b}	0.45 ± 0.02^{b}
Monate	0.26 ± 0.00^{a}	0.07 ± 0.00^{a}	0.05 ± 0.00^{b}	0.33 ± 0.07^{a}	0.02 ± 0.00^{b}	0.24 ± 0.01^{c}	0.62 ± 0.01^{a}
Mvuvhelo	0.21 ± 0.00^{ab}	0.03 ± 0.00^{b}	0.07 ± 0.00^{a}	0.26 ± 0.05^{a}	0.02 ± 0.00^{b}	0.18 ± 0.00^{b}	0.48 ± 0.00^{b}
Impilo	0.16 ± 0.02^{b}	0.02 ± 0.00^{b}	0.04 ± 0.00^{b}	0.23 ± 0.01^{a}	0.02 ± 0.00^{b}	0.13 ± 0.02^{d}	0.38 ± 0.01^{c}
199062.1	0.20 ± 0.01^{ab}	0.03 ± 0.00^{b}	0.05 ± 0.00^{b}	0.26 ± 0.02^{a}	0.02 ± 0.00^{b}	0.16 ± 0.01^{e}	0.43 ± 0.03^{b}

Same letters indicate non-significant difference, while different letters indicate significant difference at $p<0.05$

Table 3: Sugar contents (%) of seven cultivars of sweet potato grown in South Africa

Cultivars	Total Sugar (%)	Fructose (%)	Glucose(%)	Sucrose(%)	Maltose(%)
Blesbok	21.94 ± 0.56^{a}	4.03 ± 0.07^{a}	3.8 ± 0.81^{a}	12.84 ± 0.10^{bc}	1.28 ± 0.20^{a}
Bophelo	17.54 ± 0.12^{bc}	1.43 ± 0.02^{b}	0.99 ± 0.08^{b}	13.95 ± 0.05^{b}	1.18 ± 0.07^{a}
Ndou	15.84 ± 0.33^{c}	1.75 ± 0.21^{b}	0.92 ± 0.05^{b}	11.86 ± 0.00^{c}	1.31 ± 0.07^{a}
Monate	20.5 ± 0.21^{a}	3.77 ± 0.23^{a}	2.70 ± 0.13^{c}	12.97 ± 0.04^{bc}	1.07 ± 0.11^{a}
Mvuvhelo	16.74 ± 0.23^{c}	1.45 ± 0.18^{b}	0.92 ± 0.10^{b}	13.1 ± 0.12^{b}	1.26 ± 0.05^{a}
Impilo	$22.21 \pm 0.23a$	3.99 ± 0.10^{a}	3.71 ± 0.21^{a}	13.26 ± 0.02^{b}	1.25 ± 0.09^{a}
199062.1	19.02 ± 0.40^{b}	1.52 ± 0.11^{b}	1.46 ± 0.32^{d}	14.8 ± 0.14^{a}	1.24 ± 0.06^{a}

Same letters indicate non-significant difference, while different letters indicate significant difference at $p<0.05$

Furthermore, Figure 4 shows that Blesbok had the highest total carbohydrate content (76.72 %), followed by Ndou (76.09 %). The total carbohydrate contents of Bophelo, Monate, Mvuvhelo, Impilo, and 199062.1 were 69.42 %, 75.98 %, 74.51 %, 75.49 %, and 68.65 %, respectively. The total carbohydrate contents of Blesbok was significantly higher ($p<0.05$) than those of Bophelo, Mvuvhelo, Impilo, and 199062.1 and was not significantly different from those of Ndou and Monate.

The total energy values (Figure 5) of Blesbok, Bophelo, Ndou, Monate, Mvuvhelo, Impilo, and 199062.1 were 1446.42 KJ/100g, 1458.42 KJ/100g, 1451.58 KJ/100g, 1564.15 KJ/100g, 1444.38 KJ/100g, 1444.51.47 KJ/100g, and 1421.69KJ/100g, respectively. The energy contents of Bophelo and Ndou were significantly higher ($p<0.05$) than that of 199062.1 and not significantly different from those of Blesbok, Monate, Mvuvhelo, and Impilo.

The carbohydrate contents of the cultivars analysed in this study were higher than those of cultivars grown in Nigeria and Bangladesh, which were in the ranges of 20.28-35.12 %[12] and 21.10-24.50 %, respectively.[21] They were also lower than those from Brazil and Benin, which were in the ranges of 85.80-90.17 %[22] and 90.24-176.96 %, respectively.[24] Carbohydrates, which can be converted to simple forms of sugar, such as glucose, fructose, and galactose (with fructose and galactose finally converted to glucose), play an important role in the supply of energy for metabolic processes in the body. The sugar contents and the energy values of the sweet potato cultivars in this study are comparable with those in the literature.

Metabolites detection with GC-MS

The chemical compounds identified in the aqueous and aqueous-methanolic extracts of the tubers of sweet potato cultivars analysed in this study are presented in Table 4. The chemical constituents included silane, trimethylpropoxy; silane, (2-furanylmethoxy) trimethyl; propanoic acid, 2-[(trimethylsilyl)oxy]; propanoic acid, 2-[(trimethylsilyl)oxy]- trimethylsilyl ester; glycolic-acid; cyclohexene, 3,3-dimethyl-1-(trimethylsilyloxy); pentasiloxane, dodecamethyl; 3,7-dioxa-2,8-disilanonan-5-one, 2,2,8,8-tetramethyl; 4-Hydroxybutyric-Acid; silanol, trimethyl-,phosphate; furan-2-carboxylic acid, 3-methyl-,trimethylsilyl ester; glycerol, tris(trimethylsilyl) ether; butanedioic acid, bis(trimethylsilyl) ester; propanoic acid, 2,3-bis[(trimethylsilyl)oxy]-,trimethylsilyl ester; propanoic acid, 3-(trimethylsilyl)-, ethyl ester; 2-ketohexanoic acid, trimethylsilyl ester; 2-furanacetic acid, à-(trimethylsilyl)oxy]-, trimethylsilyl ester; a-eudesmol, trimethylsilyl ether; phosphonic acid, ethyl-, bis(trimethylsilyl) ester; malic acid; 2-aminophenol, O-tert.butyldimethylsilyl; gulonic acid, 2,3,5,6-tetrakis-O,(trimethylsilyl)-, lactone; myo-inositol, 1,2,3,4,5,6-hexakis-O-(trimethylsilyl); cinnamic acid, 3,4-bis(trimethylsiloxy); glycerol, tris(trimethylsilyl) ether; benzoic acid, 3,4,5-tris(trimethylsiloxy)-,trimethylsilyl ester; butanoic acid, 3-methyl-2-oxo-, trimethylsilyl ester.

These chemical compounds have health benefits. For example, glycolic acid is used in cosmetics and dermatology;[32] propanoic acid has antioxidant and antiproliferative effects;[33, 34] benzoic acid has antibacterial, antioxidant, anticancer, antiseptic, antiviral, and hepatoprotective properties;[35] and malic acid has been used in combination with benzoic and salicylic acids to treat bums, ulcers, wounds, and liver disorders.[36] In addition, the antioxidant and anticancer properties of cinnamic acid have been demonstrated.[37, 38]

Conclusion

The findings of this study indicate that the sweet potato cultivars analysed in this study have nutritional components, including crude protein, ash, fibre, and carbohydrate. These cultivars are promising alternative food source that can be used to address the problem of malnutrition. The orange-fleshed sweet potatoes cultivars (Bophelo, Impilo, 199062.1) showed the highest nutritional potentials. However, the white-fleshed cultivars (Blesbok, Ndou and Monate) generally contain more total carbohydrates than the orange-fleshed cultivars. The beneficial phytochemicals identified in the cultivars indicate the therapeutic potential of sweet potato, and access to these compounds in daily diets can contribute to improved health and wellness.

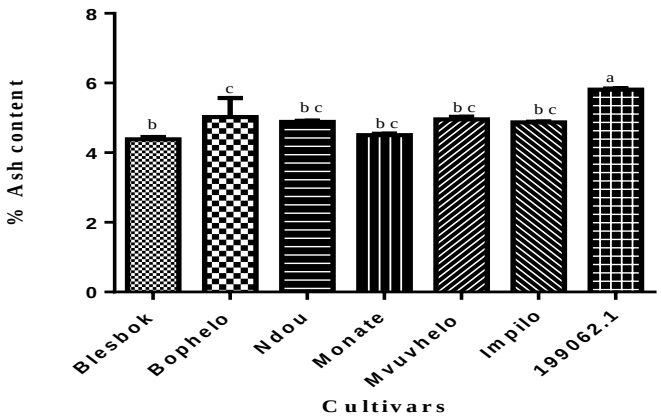

Figure 3: Ash contents of seven cultivars of sweet potato grown in South Africa

Same letters indicate non-significant difference, while different letters indicate significant difference at $P<0.05$

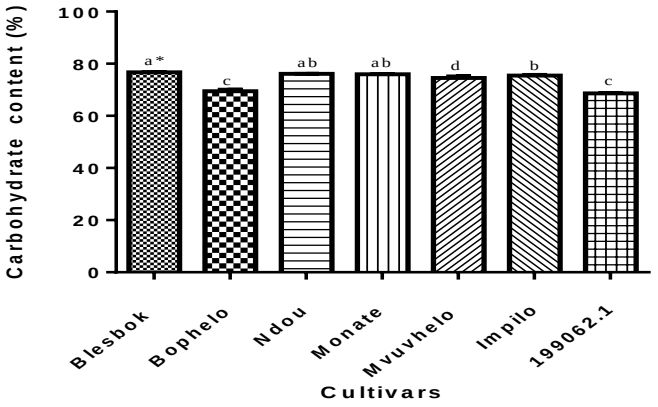

Figure 4: Carbohydrates content of seven cultivars of sweet potato grown in South Africa.

Same letters indicate non-significant difference, while different letters indicate significant difference at $p<0.05$

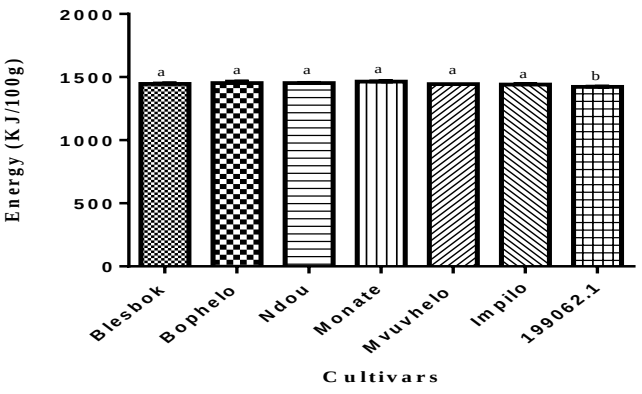

Figure 5: Energy contents of seven cultivars of sweet potato grown in South Africa.

Same letters indicate non-significant difference, while different letters indicate significant difference at $p<0.05$

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 4: Metabolites detected in cultivars of sweet potato grown in South Africa

	CHEMICAL CONSTITUENTS	MASS	BLESBOK		BOPHELO		NDOU		MONATE		MUVHELO		IMPILO		199062.1	
			A	AM	A	AM	A	AM	A	AM	A	AM	A	AM	A	AM
1	Silane, trimethylpropoxy-	117	+	+	+	+	+	+	-	+	+	+	+	-	-	+
2	Silane, (2-furanylmethoxy)trimethyl-	81	+	+	+	+	+	+	-	+	+	+	+	-	-	+
3	Propanoic acid, 2-[(trimethylsilyl)oxy]-,trimethylsilyl ester	117	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4	Glycolic-acid	147	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5	Cyclohexene, 3,3-dimethyl-1-(trimethylsilyloxy)-	183	+	+	+	+	+	+	-	+	+	+	+	-	-	+
6	Pentasiloxane, dodecamethyl-	281	+	+	+	+	+	+	+	+	+	+	+	+	+	+
7	3,7-Dioxa-2,8-disilanonan-5-one, 2,2,8,8-tetramethyl-	103	+	+	+	+	+	+	-	+	+	+	+	-	-	+
8	4-Hydroxybutyric-Acid	147	+	-	-	-	-	+	-	+	+	+	+	+	+	-
9	Silanol, trimethyl-, phosphate	299	+	+	+	+	+	+	+	+	+	+	+	+	+	+
10	Furan-2-carboxylic acid, 3-methyl-,trimethylsilyl ester	109	+	+	-	+	+	+	-	+	+	+	+	-	-	+
11	Glycerol, tris(trimethylsilyl) ether	205	+	+	+	+	+	+	+	+	+	+	+	+	+	+
12	Butanedioic acid, bis(trimethylsilyl) ester	55	+	+	+	+	+	+	+	-	+	-	+	+	+	-
13	Propanoic acid, 2,3-bis[(trimethylsilyl)oxy]-trimethylsilyl ester	189	+	-	+	-	-	-	+	-	-	-	+	-	+	-
14	Propanoic acid, 3-(trimethylsilyl)-, ethylester	159	+	+	+	+	-	+	-	+	+	+	-	-	-	-
15	2-Ketohexanoic acid, trimethylsilyl ester	143	+	+	-	-	-	-	-	+	+	-	-	-	-	+
16	á-Eudesmol, trimethylsilyl ether	130	+	-	+	+	-	+	-	-	+	-	-	-	-	-
17	Phosphonic acid, ethyl-bis(trimethylsilyl) ester	239	+	+	+	-	+	-	-	-	+	-	-	-	-	-
18	Malic-Acid	233	-	-	-	-	-	+	+	+	-	+	-	+	+	-
19	2-Aminophenol, O-tert.butyldimethylsilyl-	166	+	-	+	+	+	-	+	-	-	-	+	+	-	-
20	Gulonic acid, 2,3,5,6-tetrakis-O-(trimethylsilyl)-, lactone	81	-	-	-	-	-	-	+	-	-	-	-	-	-	-
21	Myo-Inositol, 1,2,3,4,5,6-hexakis-O-(trimethylsilyl)-	217	+	+	+	+	+	-	+	-	+	-	+	+	+	+
22	Cinnamic acid, 3,4-bis(trimethylsiloxy)-methyl ester	219	-	-	-	-	-	-	+	+	-	+	+	-	+	-
23	Glycerol, tris(trimethylsilyl) ether	205	+	+	+	+	+	+	+	+	+	+	+	+	+	+
24	Benzoic acid, 3,4,5-tris(trimethylsiloxy)-,trimethylsilyl ester	281	+	-	+	-	+	-	+	-	+	-	-	-	+	-
25	Butanoic acid, 3-methyl-2-oxo-trimethylsilyl ester	214	-	-	-	-	-	-	-	-	-	-	-	+	-	-
26	D-Arabinonic acid, 2,3,5-tris-O-(trimethylsilyl)-, c-lactone	129	-	-	-	-	-	+	-	-	-	-	-	-	-	-
27	2-Furanacetic acid, à-[(trimethylsilyl)oxy]-, trimethylsilyl ester	169	+	+	+	-	-	-	-	-	+	-	+	-	-	+

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgements

The authors appreciate North-West University, South Africa for support towards the success of this study.

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