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Comparison of antioxidant, β-carotene, and phenolic levels between roots and leaves across three popular sweet potato (*Ipomoea batatas* L.) varieties

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Abstract

Background This study aimed to compare the antioxidant activity, phenolic content, and β-carotene levels of three sweet potato varieties, namely, Beauregard, Centennial, and Georgia Jet, between their storage roots and leaves using specific methods such as ABTS assay, Folin–Ciocalteu method, and HPLC to assess the antioxidant activity, phenolic content, and β-carotene quantities, respectively.

Results Three sweet potato varieties were cultivated and collected from the University of Arkansas at Pine Bluff research fields, and their leaf extracts were used to determine total antioxidant activity (ABTS method), total phenolic content (Folin–Ciocalteu reagent assay), and β-carotene quantity (HPLC–DAD). The total antioxidant activity was more significant in the leaves than in the roots, with the leaf activity nearly doubling the roots. The Centennial variety had the highest overall average for the roots (1373 µg/g dry weight basis) and the leaves (2666 µg/g dry weight basis) for the total antioxidant activity. On the other hand, the Georgia Jet had the lowest overall average for the roots (1053 µg/g dry weight basis), while the Beauregard had the lowest activity for the leaves (1920 µg/g dry weight basis). The Beauregard roots had the highest phenolic content average (66,231 µg/g dry weight basis), while the leaves had the second-highest average (110,721 µg/g dry weight basis). The Georgia Jet had the lowest total phenolic content average for roots and leaves. The roots had a higher β-carotene quantity than the leaves. The Georgia Jet root had the highest average (1320 µg/g dry weight basis), while the leaf average was 305 µg/g dry weight basis. The Centennial variety had the lowest β-carotene quantity for both root average (1203 µg/g dry weight basis) and leaf average (218 µg/g dry weight basis). The study found that the Beauregard variety had the highest phenolic content, while the Georgia Jet had the highest β-carotene levels.

Conclusions The study concluded that sweet potato leaves have higher antioxidant activity and phenolic contents, while the roots have higher β-carotene levels. Among the varieties, Beauregard had the highest phenolic contents, whereas Georgia Jet had the highest β-carotene levels. Cultivars rich in phenolic compounds, antioxidants, and β-carotene are promising for future food security.

Keywords Antioxidant, β-Carotene, Sweet potato, Superfood, Phenolic compounds

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Background

Scientifically known as *Ipomoea batatas* L., sweet potato is a crop that plays a major role in global food security. Ranking among the top three root crops and sixth in overall food crop production worldwide, sweet potatoes are cultivated in over 115 countries [1]. Their starchy roots are known for being a great source of various dietary needs, such as starches, sugars, vitamins, iron, minerals, and fibers. According to the USDA FoodData Central, one large sweet potato (180 g) provides 162 cal, 3.6 g of protein, 37 g of carbohydrates, 3.9 g of fiber, 0.1 g of fat, 5.4 g of sugars, 1730 mcg of vitamin A, 35.3 mg of vitamin C, and 855 mg of potassium, making sweet potatoes renowned for their exceptional nutrient density [2, 3]. Sweet potatoes play a significant role in most people's diets worldwide, with an average per capita consumption of 19.4 kg/year between 2013 and 2015, and projections suggest that this consumption will increase to 21.0 kg/year by 2025 [3]. In addition, roots and tubers serve various purposes beyond human consumption. They contribute to animal feed and fulfill industrial needs, particularly as a source of starch [4]. Over the past decade, the recognition of sweet potatoes' nutritional value has led to increased cultivation by farmers, surpassing other popular traditional crops [5]. Although sweet potato leaves are sometimes used as animal feed, they are also consumed by humans in many countries worldwide and, despite often being neglected, are gaining popularity as fresh, leafy green vegetables due to their high nutritional value [6].

The sweet potato (*Ipomoea batatas*) belongs to the morning glory family, *Convolvulaceae*. It is classified as a dicotyledonous plant, which is indeed a distant relative of the common potato and shares the same order, *Solanales* [7]. Sweet potatoes are usually an annual crop in subtropical regions that have colder, unfavorable winter growing conditions. When sweet potatoes are planted in tropical regions, they can produce high yields throughout multiple growing seasons in a year. They have a fairly low requirement for work input making them a favorable crop for rural farmers [1]. The hotter, humid temperatures during the day and cooler temperatures at night can significantly increase yields, and for best development, sweet potatoes need ample light and moist soil [8]. On average, the leaf has a water content of about 80%, the stem is 88%, and the root averages around 70% [6].

Sweet potato is also a great source of resistant starch and insoluble fiber, making it a healthier and more nutritious functional food [9]. Moreover, beyond their nutritional significance, sweet potato leaves have emerged as a functional food source abundant in various vitamin and bioactive compounds, offering a plethora of health-enhancing benefits such as antidiabetic activity, antioxidant effects, anti-microbial effect, anti-cancer properties, anti-mutagenic potentials, immune modulation, hepatoprotective properties, and anti-inflammatory abilities [10]. Sweet potato roots and leaves are rich in various nutrients, with one cup (200 g) of baked sweet potato with skin providing 213% of the Daily Value (DV) for vitamin A, 44% for vitamin C, 35% for pantothenic acid, 34% for vitamin B6, and 19% for niacin [2]. Provitamin A is the source of β-carotene and is beneficial for vision, the immune system, and the reproductive system [11]. Vitamin C is an antioxidant in the body that protects cells from damage, heals wounds, and repairs bones and cartilage [12]. Vitamin B complex is vital for ensuring the body's cells function properly, like converting food into energy, creating new blood cells, and maintaining healthy tissues. In terms of minerals, one cup (200 g) of baked sweet potato with skin offers a significant amount of zinc (0.64 mg), copper (0.322 mg), magnesium (54 mg), potassium (950 mg), and iron (1.38 mg) [2, 13]. Sweet potato leaves, abundant in polyphenols, flavonoids, and carotenoids, demonstrate a range of bioactivities illustrated in Fig. 1.

The tender flesh of sweet potatoes can be white, yellow, purple, or orange, with color variations corresponding to different nutritional values [9]. Old varieties are being cross-bred to make the potatoes more drought and pest-resistant, with improved morphology, higher yield, and better storage characteristics [8]. Among popular varieties, the Beauregard, developed in 1981 at the Louisiana Agricultural Experiment Station, is widely available across the United States [17]. Other varieties, like the Centennial and Georgia Jet, are cultivated for their high yields, adaptability to short growing seasons, and suitability for specific culinary uses [18].

Naturally produced antioxidants are derived from fruits, vegetables, spices, and herbs and they are most beneficial to our body by reducing harmful free radicals and aiding in balancing the body's normal metabolic processes [19, 20]. The carotenoids, polyphenols, and vitamins are naturally found antioxidants that have numerous positive biological effects [21]. Of all the phenolic compound groups found in sweet potatoes, phenolic acids comprise the most influential group. Studies focusing on the properties of the phenolic compounds found in sweet potatoes discovered that they can help manage diabetes and some cancers. In vivo studies revealed that the phenolic compounds help regulate sugar levels, reducing insulin resistance [22]. The rich yellow and orange color in most sweet potatoes is from all of the carotenoids present [23]. α-Carotene, β-carotene, and β-cryptoxanthin are classified as provitamin A carotenoids and are converted by the body into retinol [24]. Retinol is important for collagen production and skin-strengthening

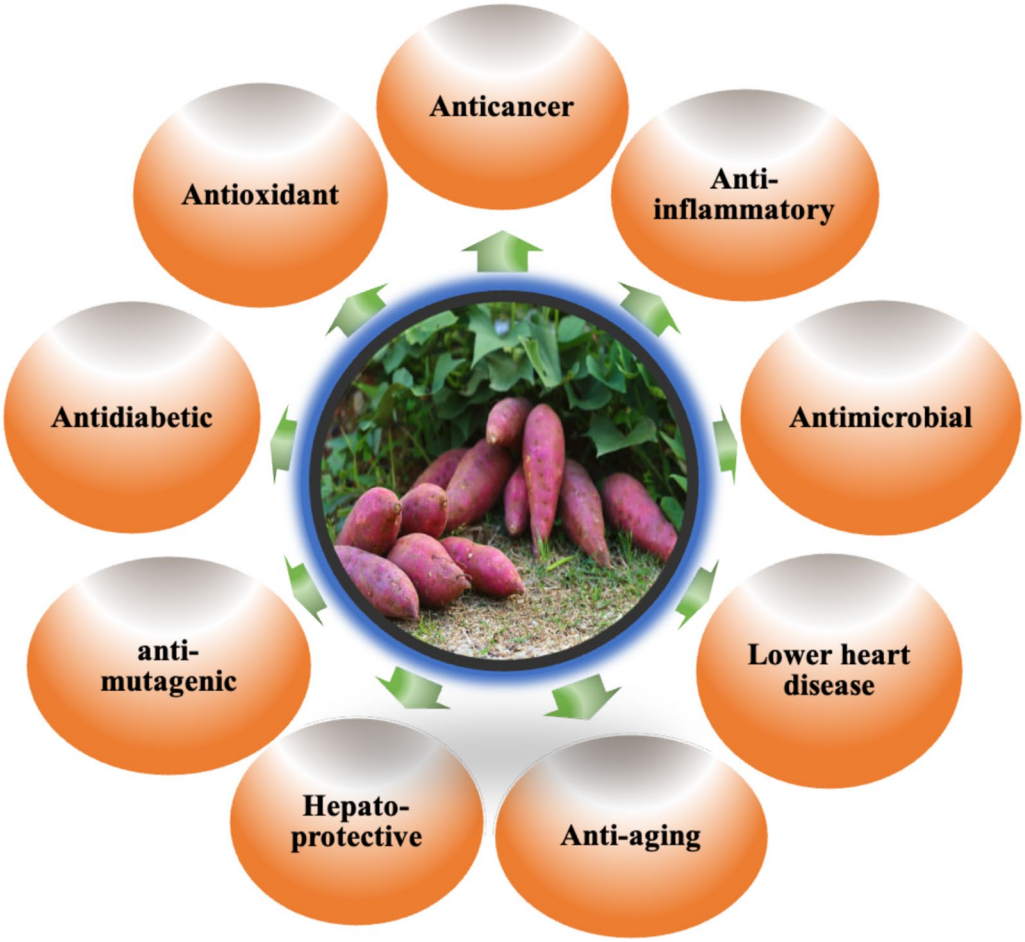

Fig. 1 Diverse health advantages associated with both sweet potato roots and leaves, highlighting their nutritional richness and potential positive impacts on human health [10, 14–16]

processing, like anti-aging, pigment correction, and acne prevention and solutions [25].

This study aimed to investigate the nutritional disparities between the roots and leaves of three sweet potato varieties: Beauregard, Centennial, and Georgia Jett. The specific objectives focused on assessing the total antioxidant activity, and total phenolic content, and identifying the carotenoids present in both roots and leaves. By analyzing these parameters, we aim to shed light on the potential health benefits and nutritional value associated with consuming different parts of sweet potatoes. Assessing the antioxidant properties and total phenolic contents of different sweet potato varieties is essential for advancing sweet potato breeding initiatives and conducting research in food processing. The findings from this study could provide valuable insights for promoting the utilization of sweet potato leaves and roots as nutritious food sources, contributing to enhanced dietary diversity and overall well-being. This data would not only enhance consumer awareness of the valuable phytochemicals found in this nutritious vegetable but also aid in selecting varieties with optimal health benefits.

Methods

Sample collection and preparation

This study analyzed leaf samples from three distinct sweet potato cultivars. These cultivars include 'Beauregard', 'Georgia Jet', and 'Centennial'. We chose these three varieties based on their popularity and availability across the United States. These varieties were cultivated in the research fields at the University of Arkansas at Pine Bluff and were harvested between June and September 2022. For each cultivar, triplicate leaf and root samples were collected directly from the field and stored for further processing. The different varieties were chosen based on their large yield sizes, which are defined as producing over 600 g of tubers per plant, and their plentiful leaf and stem selection, which is characterized by plants with over 50 leaves per plant. These criteria ensure that the selected varieties are commercially valuable and provide sufficient

leaves and tubers for analysis, improving the accuracy and reliability of the study. Small or medium yield and tuber sizes were not chosen, because they may not provide enough material for comprehensive biochemical assays, potentially leading to less reliable results. Upon collection, the leaves and roots were immediately rinsed with distilled water to remove any surface contaminants, dirt, and debris. The sweet potatoes were peeled, leaving no outer skin remaining, and then cut into small 1 cm by 1 cm cubes. The leaves were pat-dried with a paper towel and cut into small portions. After air drying at ambient temperature, the samples were frozen at -80 °C for 24 h. Following the initial freezing, the samples underwent a 48-h freeze-drying process using a MillRock Technology Freeze Dryer (Model MD3053, Kingston, NY, USA) to eliminate residual moisture. After freeze-drying, the samples were removed and mulled into smaller pieces using a pestle and mortar. The samples were ground into a fine powder using the Hamilton Beach Coffee grinder (Model: 80335R, Southern Pines, NC, USA). Finally, the powdered samples were poured into Ziploc bags and stored in the freezer at -80 °C for further analysis.

Extraction

To extract the plant materials, 70% (v/v) acetone in water as a solvent was used. The extraction was performed according to the method developed by Islam et al. [26] with some modifications. In detail, around 200 mg of the dried material was mixed with 20 ml of the 70% acetone in a 100 ml beaker. The beaker was suspended and subjected to 20 min of ultrasonic treatment using the FB120 Sonic Dismembrator (Fisher Scientific, Pittsburgh, PA) to mix the solution thoroughly. The solution was poured into a 25 ml centrifuge tube and was centrifuged at 4 °C at 3000×*g* using the IEC Centrifuge (Model-120, Fisher Scientific Co, Jiangsu, China). After 10 min in the centrifuge, the supernatant was poured into a 30 ml test tube. In the case of the sweet potato root, the supernatant was a pale orange liquid, and the supernatant of the leaves was dark green. The test tubes were stored in the refrigerator at 4 °C.

Determination of total antioxidant activity

The assessment of antioxidant capacity involved employing the trolox equivalent antioxidant capacity (TEAC) assay, pioneered by Miller et al. [27]. The first solution prepared was stock sodium persulfate (690 mM). 164 mg of solid sodium persulfate was mixed with 100 ml of distilled water in a volumetric flask. ABTS working solution (50 mM) was made by dissolving 27.4 mg of powdered ABTS in 1 ml of the previously prepared stock sodium persulfate solution in a 100 ml volumetric flask. Then distilled water was added to the flask until the solution touched 100 ml total. The ABTS solution was left to stand overnight in a dark location at room temperature. Subsequently, the solution was diluted with methanol until an absorbance of 0.736 ± 0.01 at 734 nm was attained. For each sample tested, a 10 mM stock solution of Trolox was meticulously prepared. Following this, 1 mL of the sample extract, comprising 50 µL of the crude acetonic extract of the leaves and 950 µL of methanol, was combined with 3 mL of the ABTS solution. The resulting mixture underwent incubation at 30 °C in an isotemp incubator (Model 02001, Fisher Scientific, Dubuque, Iowa, USA) for 30 min. After incubation, the absorbance at 734 nm was determined using an ASYS UVM 340 plate reader [28]. The concentration of the samples was derived from the calibration curve and expressed as

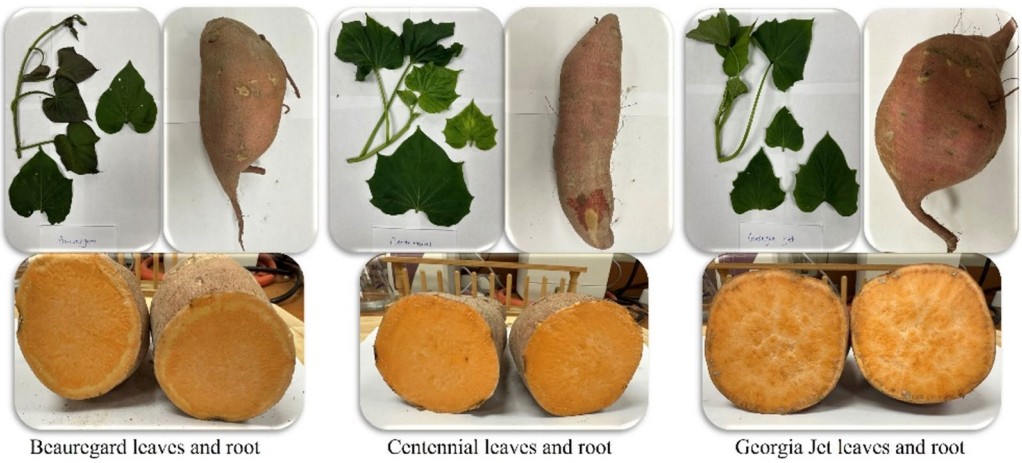

Fig. 2 Photograph of leaves, roots, and roots sectional of three sweet potato varieties used in our study. All three varieties were grown in the UAPB research field

milligrams of trolox equivalent per gram of extract (TE/g extract). The percentage scavenging of free radicals was subsequently computed using the provided equation:

$$\%\ \text{scavenging} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{The absorbance of control}} \times 100$$

Determination of total phenolic content

The investigation of total phenolic content (TPC) in-ground leaf extracts was conducted using the Folin–Ciocalteu reagent (FCR) assay, with minor adaptations [28, 29]. This assay combined 50 µL of crude leaf extract with 250 µL of FCR, followed by dilution with 950 µL of deionized water (DW). Subsequently, 1.25 mL of a 20% sodium carbonate solution was introduced, and the mixture was allowed to stand at room temperature (RT) for 40 min. The absorbance of the resulting solution was measured at 725 nm, as outlined by Makkar et al. [30]. The outcomes of this investigation are quantified and expressed as milligrams of tannic acid equivalent (TAE) per gram of extract (TAE/g extract).

Determination of total β-carotene quantity by HPLC

To identify β-carotene and determine its quantity in the samples, we employed a column chromatography method using high-performance liquid chromatography (HPLC) [31], with some modifications. The dried leaf or root samples (1 g) were mixed with Celite (Hyflo Supercell) (2 g) and acetone (15 ml), filtered by suction, and the yellow supernatant was collected. After overnight evaporation of acetone, pigments were isolated using a glass pipette column packed with glass wool and silica gel. Elution was done with a mixture of 90% hexane and 10% acetone. The eluate was collected, topped up to 50 ml with 90% hexane and 10% acetone, and stored at 4 °C. A portion of the eluate was injected into an HPLC sample vial via a 0.22 mm PTFE syringe filter for analysis. The examination of β-carotene utilized a Shimadzu HPLC setup from Shimadzu Co. Columbia, MD, USA. An analytical polymeric YMC C30 column measuring 250 mm × 4.6 mm with a 5 µm particle size was employed under ambient conditions. The mobile phases comprised 100% methanol (A) and 100% dichloromethane (B). A 1 ml/min flow rate was maintained, and the injection volume was 10 µL.

The following formula approximated the quantity of β-carotene [32]:

$$Cx(mg/g) = \frac{(Ax \times Cs(mg/ml) \times \textit{total volume of extract}(ml))}{As \times \textit{sample weight}(g)}$$

Where, Cx concentration of carotenoid X; Ax peak area of carotenoid X; Cs concentration of the standard; As peak area of the standard.

Statistical analysis

All of the experiments were conducted using three replicates per sweet potato variety. We replicated our experiments three times to ensure reliable statistical analysis. While more replicates could improve precision, logistical and resource limitations, make three replicates a practical balance between the accuracy and feasibility of our experiments. One-way analysis of variance (ANOVA) Tukey test was used to compare the variability between sweet potato varieties for β-carotene quantity, phenolic content, and antioxidant activity. For statistical comparisons, we applied analysis of variance (ANOVA) followed by Tukey's multiple comparison test using SPSS software (Version 27.0, 2022, IBM Corp., Armonk, NY, USA). As our data followed a normal distribution, and our objective involved comparing means across multiple groups, ANOVA is ideal for determining whether significant differences exist among various varieties. Statistically significant differences were defined as those with a P value of < 0.05.

Results

Phenotypic features

Three sweet potato varieties were collected from the UAPB greenhouse and planted in the UAPB farm field. The phenotypic appearances of three varieties were studied and presented in Fig. 2. The leaves are prominently different in shape, size, lamina, number of veins and color. The roots are also different in color and size.

An in-depth analysis was conducted to examine the phenotypic traits, including internode distance, leaf length, and leaf width, of leaves originating from three distinct sweet potato cultivars cultivated within the UAPB field (Table 1). The phenotypic features of different sweet potato varieties are useful for improving cultivation practices and enhancing crop productivity.

Total antioxidant activity in the roots and leaves

This study assesses the relative antioxidant capacity of extracts from the roots and leaves of three distinct sweet potato varieties in scavenging ABTS + radicals, employing Trolox as the standard antioxidant for comparison. Table 2 presents the total antioxidant activity derived from the roots and leaves of various sweet potato varieties. Each variety was represented by three samples, and the average value was recorded for

Table 1 Phenotypic traits of three sweet potato cultivars' leaves in the UAPB research field

Variety	Length of leaf (cm)	Width of leaf (cm)	Internode distance in leaf (cm)
Beauregard	$7.89 \pm 0.33^{e, f, g}$	5.99 ± 0.31^{e}	$6.80 \pm 0.32^{g, h}$
Centennial	$7.87 \pm 0.30^{f, g}$	8.95 ± 0.29^{g}	$5.77 \pm 0.27^{f, g}$
Georgia jet	$5.65 \pm 0.24^{b, c}$	$5.23 \pm 0.34^{c, d}$	$5.30 \pm 0.33^{e, f}$

Values represent the average with its corresponding standard deviation derived from three replicate measurements

The values with different superscript letters in a column are significantly different ($p < 0.05$) as measured by the Tukey test

each sample within the respective variety. Among the root samples, Centennial exhibited the highest average antioxidant activity of 1373 ± 146 µg/g on a dry-weight basis, while Georgia Jet G2 showed the lowest at 1053 ± 179 µg/g, and Beauregard had an average of 1192 ± 206 µg/g, making Centennial the highest and Georgia Jet the lowest in antioxidant content.

Among the leaf samples, Centennial had the highest average antioxidant activity at 2666 ± 136 µg/g on a dry-weight basis (Table 2), followed by Georgia Jet with 2421 ± 209 µg/g, and Beauregard with 1920 ± 146 µg/g. Thus, Centennial had the highest overall average, while Beauregard had the lowest average antioxidant activity among the three varieties. The comparison of antioxidant activity observed between the roots and leaves of the three sweet potato varieties is illustrated in Fig. 3. The graph demonstrates that the antioxidant content in the leaf samples was nearly double that of the roots for each variety.

Total phenolic content in the root and leaves

Table 2 depicts the total phenolic content obtained from the roots and leaves of the different sweet potato varieties. In terms of total phenolic content among the root samples, Beauregard exhibited the highest average at

Table 2 Total antioxidant activity, total phenolic content, and total β-carotene quantity of the three varieties of sweet potato roots

Variety	Antioxidant activity (µg/g dry weight basis)		Phenolic contents (µg/g dry weight basis)		β-carotene quantity (µg/g dry weight basis)	
	Roots	Leaves	Roots	Leaves	Roots	Leaves
Beauregard	1192 ± 206^{a}	1920 ± 146^{a}	$66{,}231 \pm 3385^{b}$	$110{,}721 \pm 9323^{a}$	1230 ± 144^{a}	246 ± 74^{a}
Centennial	1373 ± 146^{a}	2666 ± 136^{b}	$51{,}832 \pm 2886^{a}$	$100{,}586 \pm 10288^{a}$	1203 ± 111^{a}	218 ± 68^{a}
Georgia Jet	1053 ± 179^{a}	2421 ± 209^{b}	$47{,}001 \pm 2311^{a}$	$98{,}153 \pm 10705^{a}$	1320 ± 112^{a}	305 ± 110^{a}

Here, mean ($n = 3$) ± SD followed by different lowercase indicates a significant difference ($p < 0.05$) among cultivars as measured by the Tukey test

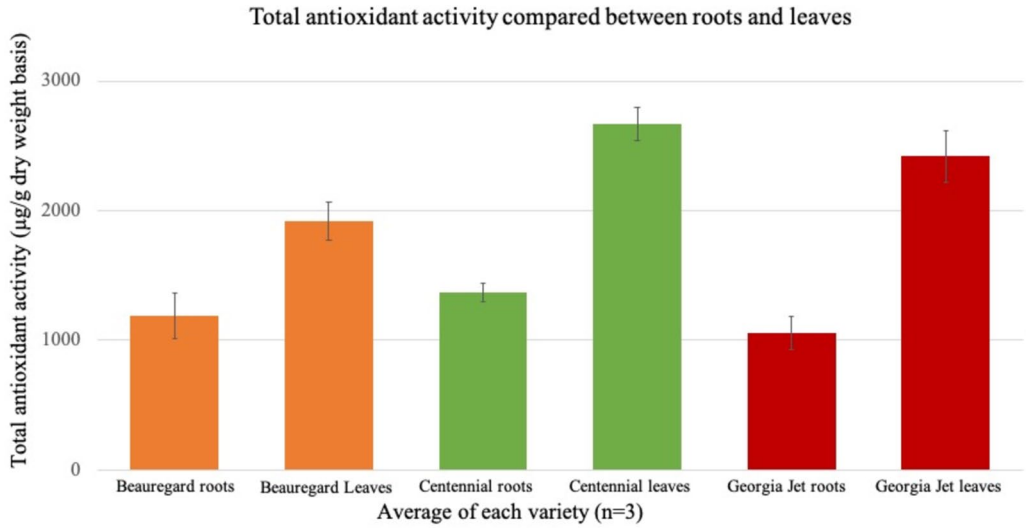

Fig. 3 Total antioxidant activity compared between the roots and the leaves of the three varieties of sweet potatoes. All values are expressed per a dry weight basis (µg/g). Each bar represents the mean value plus or minus the standard deviation (SD) derived from three independent replicates, denoted as $n = 3$

66,231 µg/g on a dry-weight basis, followed by Centennial at 51,832 µg/g, while Georgia Jet recorded the lowest phenolic content at 47,001 µg/g.

In the case of leaves, Beauregard displayed the highest average values at 110,721 µg/g on a dry-weight basis, while the Georgia Jet leaves sample demonstrated the least phenolic content at 98,153 µg/g on a dry-weight basis (Table 2). Notably, Beauregard recorded the highest average phenolic content in the leaves among the three varieties.

The differences in total phenolic content between sweet potato roots and leaves are depicted in Fig. 4. The graph distinctly shows that the leaves of each variety harbored significantly higher levels of polyphenols compared to the roots.

Total β-carotene quantity in the roots and leaves

The total quantity of β-carotene obtained in the roots and leaves of the three sweet potato varieties is presented in Table 2. The results for β-carotene content in various variety of roots were very similar, with the Georgia Jet sample exhibiting the highest average content at 1320 µg/g on a dry-weight basis, followed by Centennial at 1230 µg/g, while the lowest average was observed in Beauregard at 1203 µg/g, making Georgia Jet the highest and Beauregard the lowest in average total β-carotene quantity.

Notably, the leaves also showed closely similar results for β-carotene content in the various variety of sweet potato. Among the leaf samples, Georgia Jet exhibited the highest average concentration of 305 µg/g on a dry weight basis. Conversely, the lowest average β-carotene content was observed in the Centennial leaves, measuring 218 µg/g on a dry weight basis (Table 2). Once again, the Centennial variety displayed the lowest overall average β-carotene content among the three varieties.

The total β-carotene quantities are juxtaposed between the roots and leaves of each variety, as shown in Fig. 5. Notably, the roots harboured nearly six times more β-carotene than the leaves. Interestingly, the averages for Georgia Jet surpassed those of Centennial and Beauregard varieties in both roots and leaves.

Discussion

Sweet potato leaves are comprised of numerous antioxidants, all working to maintain a healthy body by ridding it of toxic free radicals. Data from this study following the ABTS method, Trolox equivalent antioxidant capacity assay, expresses that the leaves had significantly more antioxidant activity than the roots, as per Fig. 3. Similarly, earlier research also observed that sweet potato leaves exhibited higher antioxidant activity than peel and root tissues across various sweet potato varieties [33]. This underscores the richness of antioxidants within the leaves. In addition, the leaves and stems of sweet potatoes are abundant sources of antioxidants, dietary fibers, minerals, proteins, and vitamins [34]. A study examining the change in antioxidant and phenolic properties of sweet potatoes from different heat treatments tests the scavenging capacity of antioxidants via the DPPH (2,2′-diphenyl-1picrylhydrazyl) method and the FRAP (ferric reducing antioxidant power) assay [35]. The average DPPH method

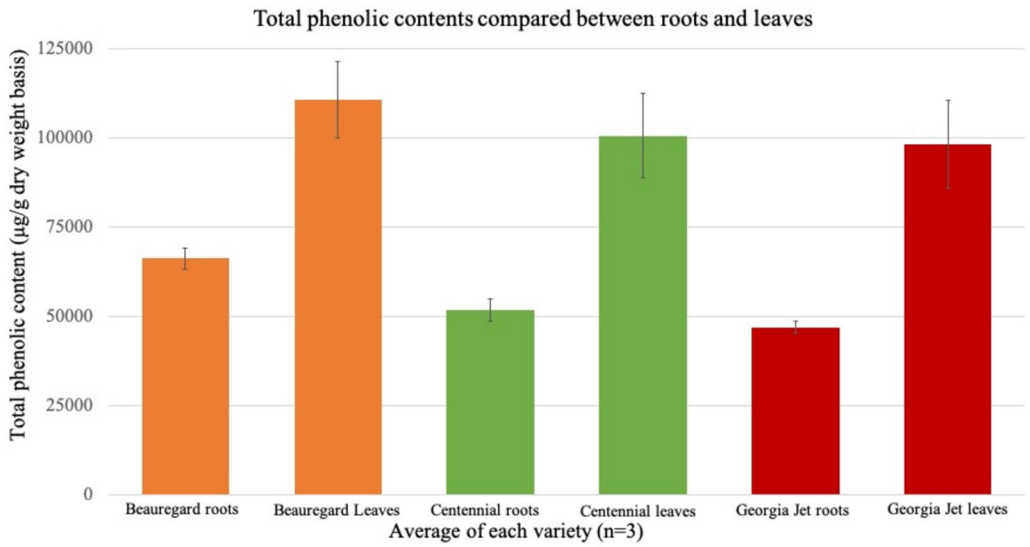

Fig. 4 Total phenolic content compared between the roots and the leaves of the three varieties of sweet potatoes. All values are expressed per a dry weight basis (µg/g). Each bar represents the mean value plus or minus the standard deviation (SD) derived from three independent replicates, denoted as $n = 3$

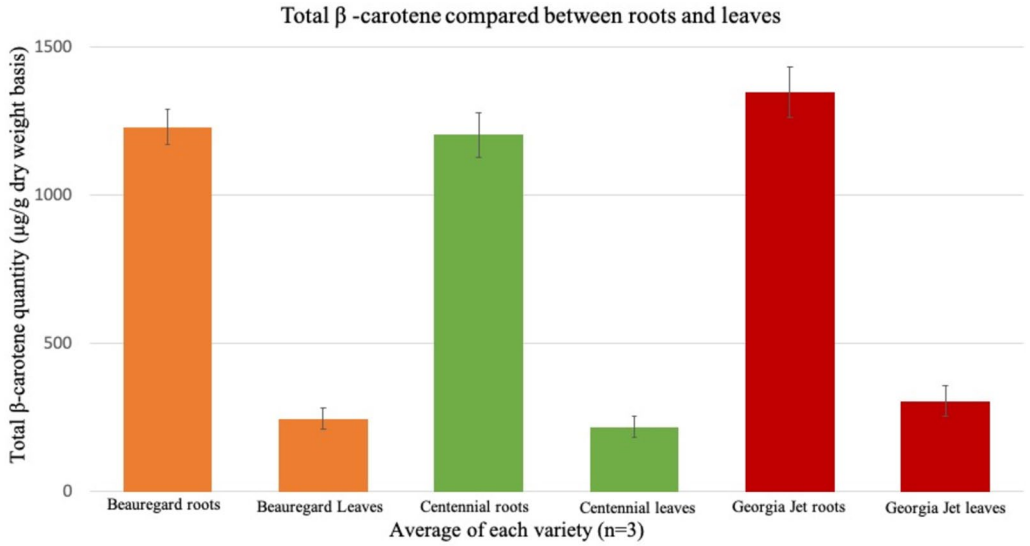

Fig. 5 Total β-carotene quantity compared between the roots and the leaves of the three varieties of sweet potatoes. All values are expressed per a dry weight basis (µg/g). Each bar represents the mean value plus or minus the standard deviation (SD) derived from three independent replicates, denoted as $n = 3$

for antioxidant activity found 1.76 ± 0.03 µmol TE g^{-1} DW and 3.25 ± 0.07 µmol TE g^{-1} DW for the Beauregard variety. Both results were calculated according to the Trolox calibration curve [35]. Another report detailed the antioxidant content in the leaves and petioles before and after blanching following the DPPH radical scavenging activity assay. The average data for sweet potato leaves before blanching was 0.13 ± 0.00 EC_{50}, mg/mL, and the EC_{50} value was the effective concentration of the sample for a 50% reduction [33]. The leaves have greater concentrations of radical scavenging capabilities than the tubers in several varieties, including Covington, Beauregard, and Hernandez [36]. This research study identifies that the Centennial and the Georgia Jet varieties also fit the statement that the leaves have higher antioxidant activity than their root counterpart. Sweet potatoes come in various flesh colors, which may significantly impact their health benefits.

Sweet potato leaves took the top seed over the tuber for the highest total phenolic content. Results were obtained by following the Folin–Ciocalteu method, tannic acid equivalent. Other studies concluded that the total phenolic content was highest in the leaves, and to be followed by the peel, whole root, and lastly, the flesh [36]. A study examining the change in antioxidant and phenolic properties of sweet potatoes from different heat treatments was tested utilizing the colorimetric method, with the gallic acid equivalent (GAE) per gram of dry weight. The total phenolic content in the root of the Beauregard variety was 0.413 ± 0.02 mg GAE g^{-1} DW [35]. In another report, the antioxidant content in the leaves and petioles before and after they were blanched was detailed following the colorimetric method with the chlorogenic acid equivalent (CAE) per 100 g of fresh weight. The total phenolic content for the leaves ranged between 0.65 and 1.91 g CAE/100 g FW [33]. Light exposure and cooler temperatures can affect the phenolic concentrations in sweet potato, causing levels to lower slightly [12, 37]. Different food treatments and handling techniques can also affect the total phenolic content of the sweet potato [38]. For example, leaves that were steam-cooked had a slight increase in the total phenolic concentrations [36].

The roots of the three sweet potato varieties had immensely higher β-carotene levels than the leaves. The β-carotene was identified and quantified following column chromatography, a high-performance liquid chromatography technique. The overall carotenoid content fluctuates based on the color of the sweet potato. The Orange-fleshed potatoes have the highest quantity of β-carotene; in purple-fleshed potatoes, trans-β-carotene is the leading carotenoid [12]. Research regarding the retention of carotenoids in sweet potato flesh through different processing methods; used column chromatography with aluminum oxide and elute to find the β-carotene present in fresh weight per 100 g. The β-carotene quantity varied from 5.85 to 13.63 mg/100 g.f.w. and it found that β-carotene made up more than 80% of the total carotenoids [39]. A report on the bioactive compounds, antioxidants, and health benefits, and a breakdown of all the vitamins and minerals in sweet potato leaves are listed. It states that an average of 0.273–0.4 mg/100 g DW of β-carotene is present in sweet potato leaves [10].

β-Carotene concentration can be affected a fair amount by different processing factors. Sun-drying caused the most extensive loss, losing up to 37% of the original β-carotene concentration, and oven-drying caused the slightest loss of only 4% [39]. The extreme concentration of β-carotene and other provitamin assets in the typical orange-fleshed has attracted much research.

One of the main benefits of sweet potatoes is its high nutrient levels. Two of the most commonly compared attributes of nutritious vegetables are their polyphenol concentration and the β-carotene. Compared to the polyphenol concentration of grape seeds, sweet potato leaves have 7 to 9 times more [37]. Grape seeds are known for their high polyphenol count, which makes this significant. Sweet potatoes also have a very high b β-carotene count of 22.6 mg per 100 g serving, compared to carrots with 8.3 mg per 100 g serving, according to the USDA Nutrient Database for Standard Reference (Release 27). The findings show that in similar quantities, the sweet potato tends to have an edge in several main nutritional categories.

Conclusions

This study examined the antioxidant activity, phenolic content, and β-carotene levels in three sweet potato varieties: Beauregard, Centennial, and Georgia Jet-comparing these compounds between roots and leaves. Our results confirm previous research indicating that sweet potato leaves contain significantly higher antioxidant activity than roots, which is consistent with previous research [33]. In addition, our finding that roots have higher β-carotene levels aligns with reports from earlier studies that emphasize the nutrient density of sweet potato roots [34, 40].

These results underscore the potential of sweet potato, especially its underutilized leaves, in enhancing dietary diversity and food security. Because of their high phenolic and antioxidant content may help prevent diseases linked to oxidative stress, treat hidden hunger and promote a healthy diet [41]. Finally, sweet potatoes may be an excellent way to address food scarcity and nutritional inadequacies by encouraging the consumption of roots and leaves, especially in areas with high malnutrition rates. Future research might examine these advantages in more detail, supporting the inclusion of sweet potato cultivars rich in phenolic compounds, antioxidants, and β-carotene in dietary and agricultural plans for long-term food security.

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Not applicable.

Author contributions
KLH performed the experiments, collected the sample and generated the data. MA summarized the data, organized the manuscript and was a major contributor in writing the manuscript. TS collected and analyzed sweet potato leaves and root samples and helped in the experiments. SI organized and mentored the research, reviewed the manuscript, provided suggestions and supervised all over the project. All authors read and approved the final manuscript.

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Availability of data and materials
The data sets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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