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Nutritional Properties and Antioxidant Activity of Seven Sweet Potato Cultivars and Clones (*Ipomoea batatas* L.)

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ABSTRACT

The current work aims to evaluate the yield of sweet potato genotypes (clones) which suitable for human and animal feeding and compare it with local cultivar, in addition to determine the antioxidant activity and active ingredients in different sweet potato cultivar. Egypt is a densely populated developing country and needs food for more than 100 million people. We introduce in this research two cultivars and 5 clones promising to supply the population with food. Two years of field trials 2018 and 2019 were achieved at the Research Farm, Sids Horticulture Research Station, ARC, Egypt. Twenty-six property (8 vegetative criteria) and 18 chemical constituents were evaluated. Dark orange-fleshed Beauregard cv. recorded the highest values for many vegetative properties and chemical constituents such as the number of branches/plant, total marketable yield (kg/plot), total yield, total starch, inulin, and secondary metabolites. From the results, it can use Beauregard, Abees, SP1 and SP4 as a source of phenolic compounds and total flavonoids (TPCs conc. 25.75 – 122.17 mg/g in skin extract, 25.42 – 52.33 mg/g in flesh extract and TFs conc. 8.33 – 106.15 µg/g in skin extract, 6.22 – 61.81 µg/g in flesh extract). The order of antioxidant activity of the clone extracts was found to be in the skin extract as follows, Beauregard > Sp1 > Sp2 and in the flesh extracts as follows, Beauregard > Abees at high concentration of extract (50 µg/ml) However, Beauregard skin extract showed the highest FRAP (Ferric Reducing Antioxidant Potential) value (922.43 µM trolox/100 g dry weight) and (748.43 µM trolox/100 g dry weight) in the flesh extract. The Beauregard extract possesses a significant free radical scavenging ability (20.78%) compare to the standard trolox (95.5%). The samples under study are of great food preference and that the sweet potato contains many compounds and pigments such as anthocyanin due to which the antioxidant effect is attributed and which enhances the nutritional value of these strong candidate samples in developing countries such as Egypt and African countries. And that we recommend the use of sweet potatoes in daily feeding, with a preference for colored items that contain pigments over those not colored.

KEYWORDS: Sweet potato, Flavonoids, FRAP, *Ipomoea batatas* orange-fleshed, Phenolic compounds.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant belonging to the *Convolvulaceae* family [1]. The plant is an herbaceous perennial vine with alternate heart-shaped leaves. Sweet potato ranked as the seventh economic crop after wheat, rice, maize, potato, barley, and cassava [2]. In 2015, 105 million tons of sweet potatoes were produced worldwide and 95% thereof in developing countries with China as the lead producer [3].

Sweet potato is one of the important root crops in Egypt and many other countries in the world especially the Eastern and Southern parts of the African continent [4]. Sweet potato requires low inputs and less management and is an important food security crop grown in many of the poorest regions of the world mainly by women for food and as a source of food and family cash income [1]. Sweet potato is valued for its roots which can be boiled, fried, baked, or roasted for humans or boiled and fed to livestock as a source of energy [5]. The varieties of sweet potato may vary in their flesh or storage root skin color, and some by origin [6]. Its flesh ranges in color from beige to white, purple, red, pink, violet, yellow, and orange. Recent research results indicate increased availability of beta-carotene (Provitamin A) and crude protein for good nutrition and health [7, 71]. Orange-fleshed varieties are rich in beta-carotene, while purple-fleshed varieties are high in anthocyanins, two important antioxidants thought to prevent chronic heart diseases and cancer [8, 70]. Significant amounts of essential minerals are found in sweet potato, including manganese, copper, iron, and potassium, which are the most prevalent mineral [9].

The total cultivated area in the year of 2017 reached about 18590 feddan with a total production of about 287244 tons and a mean of 9-17 tons/fed. Sweet potato cultivated area in Egypt El-Behera, Kafr–Elsheikh, and Damietta governorates

(Department of Agricultural Economic statistics, Ministry of Agric., Egypt [10]. A large amount of variation exists within the sweet potatoes [11, 12]. Differences those are easy to determine to include vine characteristics, leaf morphology, storage root shape, and color [13]. Other characteristics not as easily detected include variations in the resistance of different sweet potato varieties or genotypes to insect pests and diseases. In Egypt a proper understanding of these variations would assist the selection of the appropriate sweet potato types, improve the agronomic practices and contribute to improved crop establishment and increased export yields and local consumption yield. The fresh tuberous root contains 80 to 90% carbohydrate of dry matter [14]. Numerous researchers verified the effect of sweet potato genotypes on root yield, yield component and plant phytochemical constituents of many species [14, 15-23].

The main objectives of the present work were, to (a) evaluate some high–yielding sweet potato genotypes (clones) suitable for human and animal feeding, and industrial purposes or for exportation (abroad marketing). (b) Compare theses genotypes with the common local cultivars; Beauregard and Abees by determining their chemical, eg, sugars, starch, inulin, nitrate, nitrite, and Vitamin C. (c) assay the levels of some secondary metabolites such as total anthocyanins, total flavonoids, and total phenolic compounds. (d) Determine the antioxidative activities of some chemical compounds which sweet potato is rich in.

2. MATERIALS AND METHODS

2.1. Plant Materials

Five local sweet potato clones (SP1, SP2, SP3, SP4, and Sp5, and two local commercial cultivars (Beauregard and Abees) were used in recent study. All clones were collected from various provinces in Egypt where they have been commonly grown for several decades. Landraces of sweet potato were a kind gift of (Dr. Abbas Z. Osman Prof. of Vegetative Crops, Vegetable. Res. Dep., Hort. Res. Inst., Sids Hort. Res. Station, Agric. Res. Center, Giza, EGYPT). Source of collection and color characteristics of the seven sweet potato samples are shown in Table (1).

Table 1. Source of collection and color characteristics of the seven sweet potato samples.

Sweet potato/samples	Source of collection	Skin color	Flesh color
SP1	El-Behera Gov.	Purple	Purple
SP2	Beni–Suef Gov.	white Red	White
SP3	El-Minia Gov.	Red	Yellow
SP4	El- Minia Gov.	Red	Cream
SP5	Kafer-El-sheikh Gov.	White	White
Beauregard	El-Behera Gov.	Orange	Dark Orange
Abees	E;- Minia Gov.	Red	Orange

Field trial layout

Two years field of trials 2018 and 2019 were achieved at the Research Farm, Sids Horticulture Research Station, Agriculture Research Center, Beni-Suief Governorate, and Egypt. To investigate the yield and quality parameters on some sweet potato clones for export under middle Egypt conditions. The soil of the experimental field was clay loam in texture. The physical and chemical analysis of the soil was determined according to the methods described by [24]. As shown in Table (2).

Table 2. The physical and chemical properties of the experimental soil during 2018 and 2019 seasons

Chemical analysis						
Sand %	**Silt %**	**Clay %**	**Texture**	**OM**	**pH**	**E.C mmhos/cm**
20	31.0	49.0	Clay loam	1.47	7.70	1.03
22.0	32	46.0.	Clay loam	1.67	7.80	1.0
Available nutrients						
N %	**P ppm**	**K ppm**	**Mn ppm**	**Fe ppm**	**Zn ppm**	
0.07	28.21	384.4	19.1	32.1	6.4	
0.09	29.25	380.5	21.2	33.0	6.5	

Each clone and the commercial cultivar Beauregard and Abees were vegetatively propagated to produce large numbers of high-quality sweet potato transplants (cuttings). Cuttings (20 cm length) with at least three nodes were taken from the nursery and transplanted to the soil during May 20, 2018, and May 26, 2019 seasons.

The experimental scheme was a randomized complete blocks design (RCBD) with three replicates. The transplants were placed at 25 cm spacing in rows. Each experimental plot included four rows 4 m long and each row 75 cm wide with an area about 12 m^2 for all samples. Agricultural practices were followed as recommended by the Egyptian Ministry of Agriculture. At harvest time (160 days from

transplanting), five plants from each plot were randomly taken in which the following data were recorded as averages:

2.2. Vegetative characters

1-Number of branches/plant.
2-Main stem length (cm).
3-Vines weight/plant.

2.3. Yield and its components

1- Root length (cm).
2- Diameter of marketable roots (cm).
3- Number of marketable roots/plant.
4- Weight of marketable root/plant (g).
5- Total marketable yield (kg/plot) and yield / fed as (ton/fed.).

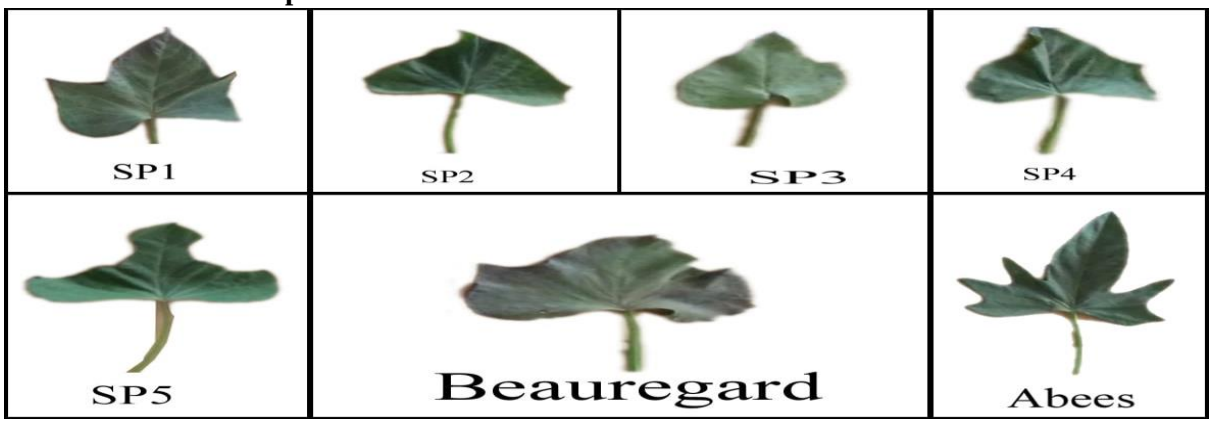

Plate (1): Leaf morphology of the seven sweet potato samples.

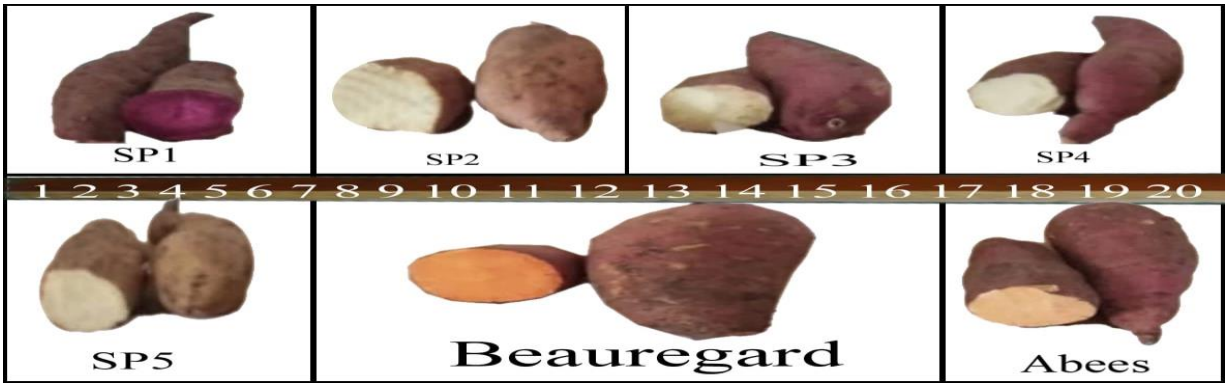

Plate (2): Root colors characteristics of the seven sweet potato samples.

2.4. Proximate Analysis.

1- Determination of moisture.
2- Total ash content.
3- Total crude fibers.
4- Total crude lipids.
5- Crude protein (N x 6.25) were determined according to (25).

Determination of soluble sugars

Soluble sugars were extracted according to [26] method. Total soluble sugars were determined by the phenol-sulfuric acid method described by [27]. Total reducing sugars were determined by modified Neocuproine method described by [28]. Total non-reducing sugars (TNRS) were calculated by subtracting the total reducing sugars (TRS) from the total soluble sugars (TSS).

Determination of starch

Starch was extracted in 72% (v/v) perchloric acid at room temperature. Quantitative determination of starch was carried out according to the colorimetric method of [29].

Determination of inulin by enzymatic spectrophotometric method

The fructan contents (inulin) in the sweet potato extracts were assayed using the enzymatic spectrophotometric method [30]. Method (999.03) using Megazme fructan assay kit (Megazyme, Ireland). The samples were extracted using the same procedure along with the samples [31].

Determination of nitrite NO_2 and nitrate NO_3

The nitrite and nitrate were extracted from sweet potato roots by 1% (wt/wt) K_2SO_4 solution and determined as described by [32].

Determination of vitamin C

Vitamin C was extracted using 1.25% (v/v) oxalic acid solution. The indophenol method (2,6-dichlorophenol indophenol) as described by [33], was used for determination of ascorbic acid concentration in sweet potato. All determinations were performed in triplicates and the mean values were recorded.

2.5. Phytochemical analysis

Preparation of plant extract

Five local sweet potato clones (SP1, SP2, SP3, SP4, and Sp5) and two local commercial cultivars (Beauregard and Abees) were collected at the harvest maturity period, whole fruit were frozen in liquid N_2 and grinded using Grinder (Metuchen, NJ, USA). The extraction process of 20 g/100 ml methanol was used and shake for 24 h at 25 ° C, then filtered using Whatman paper (Thomas Scientific, USA), the supernatant was dried using rotary evaporator and speed vacuum. Then stored at 4° C. 10 mg/ml DMSO were dissolved for further analysis.

Total phenolic content (TPC)

Following the Folin-Ciocalteu colorimetric method, TPC of samples were measured [34] with minor modification for 96-well micro-plates. Briefly, 15 µl of diluted samples were placed into wells of 96-well micro- plates (GS , USA).Consequently, 240 µl of Folin was added and left for half an hour in darkness at ambient temperature. Then, 15 µl of Na_2CO_3 20% (wt/wt) were added to each well, adjust the micro-plate reader at shaken mode before start reading the TPC concentrations. The absorbance was measured at λ=755 nm with the micro-plate reader ACCURIS Smart Reader (Edison, NJ, USA). TPC was calculated using a standard curve set of serial dilutions of gallic acid (GAE). TPC values were performed in triplicate and expressed as [mg GAE/g(FM)].

Estimation of total flavonoid content (TFC)

Following previously described method **[35]**. To determine the content of total flavonoid with minor modifications. 25 µl of samples were added to 75 µl of MeOH 96% (v/v). Then, 5 µl of 10% Aluminium Chloride and 5 µl of potassium acetate ,then 140 µl with distilled water. Kept for half an hour in darkness at 25°C, the readings was measured at λ=415 nm. TFC content was calculated using a standard curve prepared using gradient dilutions of quercetin. The TFC was presented as mg QE/g (FM).

DPPH radical scavenging activity assay

The antioxidant activity was measured by DPPH radical scavenging activity [36]. The stock solution was prepared using 10 mg / 1 ml DMSO. Serial dilutions (a 96-well plate, achieving 100, 50, and 25 µg/ml final concentrations) for each extract was prepared. Readings was measured using at λ=515 nm. % DPPH inhibition = $[1-(A_{sample}-A_{background})/(A_{DMSO}-A_{background})] *100$. Calibration curve was obtained using the inhibition rate values of the standard Trolox solution.

Ferric Reducing Antioxidant Potential FRAP

FRAP assay was performed for evaluating the total antioxidant activity. The assay is established on the reducing power of the antioxidant. A powerful antioxidant reduces the ferric ion (Fe^{3+}) to ferrous ion (Fe^{2+}); the latter forms a blue complex (Fe^{2+}/TPTZ), which increases the absorption at 593 nm. Briefly, 20 µl of sample solution were added to the 96-well micro-plate followed by 280 µl of working FRAP solution. The mixtures were shaken, incubated at 37°C for 30 minutes in darkness, and then absorbance was measured using a 96 well micro-plate reader [37-39]. FRAP solutions were prepared as described previously [40, 41]. FRAP working solution was prepared daily and warmed at 37 C° for 10 minutes before use by mixing acetate buffer (300 mM, pH 3.6) , TPTZ (2,4,6-tripyridyl-*S*-triazine) (40 mM dissolved with 40 mM HCl), and ferric chloride (20 mM in water) [(10/1/1 v/v). The FRAP working solution was prepared. The calibration curve was obtained using the inhibition rate values of Trolox.

Total anthocyanins quantification

Total anthocyanin analysis was performed following the method described by [42] using total anthocyanin chemical kit (BQCkit Anthocyanins Assay kit *KB-03-0159)*. The absorbance value (A) of the sample can be calculated using the following equation:

$$A' = (A_{510\,nm}\ \text{Reagent A} - A_{700\,nm}\ \text{Reagent A}) - (A_{510\,nm}\ \text{Reagent B} - A_{700\,nm}\ \text{Reagent B})$$

Total anthocyanins in mg/L calculated as equivalent of Cyanidin 6-O-glucoside is:

$$[\text{anthocyanins}]\ (mg/L) = [A' \times (DF) \times 449.2 \times 1000]/26900$$

Total Monomeric Anthocyanin Content can be calculated as mg of cyanidin-3-O-glucoside (C3G) per L of sample using a molar extinction coefficient (ℰ) 26,900 $Lcm\text{-}1mol^{-1}$, molecular weight (MW) 449.2 $gmol^{-1}$ for C3G, path length (l) in cm and the appropriate dilution factor (DF).

2.6. Statistical analysis

Data obtained were subjected to analysis of variance method and the means were compared, using the Duncan's multiple range tests, through the procedures [43].

3. RESULTS AND DISSECTION

3.1. Vegetative characters

The average number of branches/plant, mean of stem length (cm) and vine weight (kg) /plant were affected by the studied clones, compared with the commercial cultivar Beauregard and Abees (Table 3).

Table 3. Average number of branches/plant, mean of stem length (cm) and vine weight (kg/plant) of the tested sweet potato clones and the two local commercial cultivars Beauregard and Abees in the first and second seasons.

Clones/cv.	No. of branches/plant		Main Stem length (cm)		Vine weight (kg/plant)	
	2018	2019	2018	2019	2018	2019
SP1	**13.6 b**	**13.1ab**	**340 a**	**332 a**	**5.0 a**	**6.5 a**
SP2	10.2 e	9.9 d	192.7 e	310.0 b	2.0 ef	2.7 e
SP3	11.3 d	11.4 c	312.3 b	308.3 b	3.3 c	3.8 c
SP4	13.3 b	13.0 b	187.7 e	261.7 c	1.8 f	2.2 f
SP5	8.5 f	8.0 e	203.0 d	198.3 d	2.2 e	3.0 de
Beauregard	14.7 a	14.0 a	317.0 b	178.3 e	4.2 b	5.5 b
Abees	12.6 c	12.4 b	265.3 c	172.7 e	2.8 d	3.3 d

* In a column, values followed by the same letter are not significantly different, using Duncan's multiple range test at 0.05 level.

Beauregard cv. recorded the highest values for the number of branches/plant compared to the five clones and cv. Abees in the first and second seasons, with significant differences among them. SP1 clone recorded higher branches number/plant than those of the other four clones and Abees cultivar. SP1 clone surpassed in the stem lengths and vine weights in the two seasons on the six other samples because of these properties this clone could be used as a leafy vegetable or for animal feed. Due to its rapid growth and tendency to cover the land in a short time, it might be used as a cover crop to reduce erosion [44]. On the other hand, estimates for stem length and vine weight/plant showed that Abees cv. gave significantly lower values than those for the tested clones.

3.2. Yield and its components

3.2.1. Root size (length and diameter (cm)

Data stated in Table (4) show that there were significant differences among the tested sweet potato clones in all characters under this study, i.e., root size (length and diameter (cm).

Table 4. Root size, length and diameter (cm) of some sweet potato clones and the commercial cultivar Beauregard and Abees in the first and second seasons.

Clones/cv.	Root size (cm)			
	Root length (cm)		Diameter of marketable roots (cm)	
	2018	2019	2018	2019
SP1	25.7 a	28.0 a	6.4 bc	6.8 b
SP2	11.3 e	12.0 d	4.5 d	4.2 d
SP3	18.3 c	18.7 c	4.5 d	4.4 d
SP4	25.0 a	23.3 b	6.9 b	7.0 b
SP5	13.7 d	13.3 d	3.7 d	3.6 d
Beauregard	22.3 b	23.3 b	8.7 a	8.2 a
Abees	21.0 b	22.0 b	5.5 c	5.7 c

* In a column, values followed by the same letter are not significantly different, using Duncan's multiple range test at 0.05 level.

The highest root length was produced in both seasons in SP1 clone without significant differences between SP4 clones in the first season only. However, Beauregard cv. gave significantly higher values for root diameter in two seasons.

3.2.2. Root number/plant, weight of marketable root kg/plant, and total yield (ton/fed.)

Root number/plant, weight of marketable root (kg/plant), and total yield (ton/fed.). For the four studied clones compared to the local commercial cultivars are illustrated in Table (5). There were significant differences among the tested clones and two commercial cultivars Beauregard and Abees in the three mentioned characters in the first and second seasons. These results are in agreement with [45] who suggested that sweet potato cultivars varied significantly in total yields. They contribute to the increase in total yield due to the increase in root weight and depend on leaf photosynthesis. Also, [46] reported that the canopy type might affect the NAR (Net Assimilation Rate) of each cultivar.

Nowadays, the plant breeders concern on two approaches first is the production and improving high yielding clones and the second approach is the quality of tuber roots of sweet potatoes [47] who stated that the breeding for improving yield and quality in sweet potato (*Ipomoea batatas*, (L) Lam) is an obligation not luxury recent studies highlighted the especially high levels of β-carotene in orange varieties and lead up to the incorporation of sweet potato into the program to prevent vitamin A deficiency in Africa [48] Since then, one of the main focuses of sweet potato breeding was raise of starch and DM content whilst maintaining high provitamin A levels.

Table 5. Number of marketable root/plant weight of marketable roots (kg/plant) and total marketable yield (ton/fed.) of the some sweet potato clones and Beauregard and Abees in the first and second seasons.

Clones/cv.	Number of marketable root/plant		Weight of marketable root (kg/plant)		Total marketable yield/ (ton/fed.)	
	2018	2019	2018	2019	2018	2019
SP1	7.3 c	7.7 c	1.8.0 ab	1.7 bc	16.0 c	17.7 c
SP2	4.1 de	4.3 ef	0.533 d	0.580 e	8.7 e	7.9 e
SP3	4.8 d	4.9 e	0.70 cd	0.730 de	10.0 e	11.3 d
SP4	9.8 b	9.0 b	2. 0 ab	2.1 ab	23.3 b	24.0 b
SP5	3.4 e	3.6 f	0.387 d	0.400 e	7.5 e	7.6 e
Beauregard	11.0 a	11.3 a	2.5 a	2.6 a	27.3 a	29.0 a
Abees	6.3 c	6.5 d	1.4 bc	1.3 cd	12.7 d	13.7 d

* In a column, values followed by the same letter are not significantly different, using Duncan's multiple range tests at 0.05 levels.

3.3. The chemical constituents of sweet potatoes

Five chemical constituents of 7 sweet potato samples were analyzed and the results showed that crude protein (CP) ranged from 3.359 to 4.059% (Table 6). The highest level of CP was in SP4 and the lowest one was in SP5. The results also showed that Beauregard (established cultivar) has the highest values for DM, TAC, TCF, and TCL. The data indicated that dry matter values were in close extent and ranged from 26 to 31%.

Table 6. Approximate analysis of sweet potato samples

Clones/cv.	Approximate analysis (%)				
	DM	TAC	TCF	TCL	CP
SP1	26.33±1.2	0.987±0.08	1.989±0.18	0.979±0.09	3.499±0.35
SP2	28.45±1.4	0.966±0.09	1.239±0.12	0.849±0.08	3.799±0.38
SP3	29.56±1.5	0.898±0.07	1.529±0.15	0.739±0.08	3.679±0.37
SP4	27.21±1.3	0.984±0.08	1.649±0.16	1.129±0.11	4.059±0.40
SP5	29.87±1.4	0998±0.09	1.759±0.17	1.359±0.14	3.359±0.36
Beauregard	31.59±1.6	1.329±0.11	2.001±0.21	1.879±0.19	3.559±0..36
Abees	30.55±1.5	1.188±0.10	1.879±0.17	1.239±0.12	3.569±035

* DM= Dry matter; TAC= total ash content; TCF= total crude fiber; TCL= total crude lipids and CP= crude protein.

These results are within the range reported by [49, 50, and 18]. The average dry matter content in tuber is approximately 30% but varies widely depending on such factors as cultivar, location, and climate [51] Results of [52] on composition of selected new five sweet potato varieties showed significant differences among these varieties in protein contents. Sweet potatoes are not considered a good source for crude lipids and crude fiber, which did not exceed 1.87-2.0%, respectively.

The chemical approximate of sweet potato are widely depending on several factors such as cultivars, composition of soil, climate, and cultivation practices [53-55].

Sugar contents

Total soluble sugars (TSS), total reducing sugars (TRS), total starch, and inulin were assayed and the results are shown in Table (7). The highest values for TSS, TNRS total starch and inulin were recorded in tuber roots of dark orange-fleshed Beauregard cultivar. Our results are in good agreement with those reported by [56, 53] evaluated two commercial Egyptian cultivars for root chemical composition and sugars. Variability in total sugars between sweet potato samples was notable and the estimates ranged from 0.38% to 5.64% fwb among many cultivars [56, 1]. It was also reported the considerable variability in total sugars existed even within different roots of the same cultivar. Sweet potato is high in starch, 30-50% greater starch yield than rice, corn, and wheat starch sources measured under the same conditions [57].

Table 7. Sugar levels of sweet potato clones

Clones/cv.	Carbohydrate contents (%)				
	TSS	TRS	TNRS*	Total starch	Inulin
SP1	4.85±0.45	3.52±0.32	1.33±0.14	19.78±1.1	0.339±0.003
SP2	4.92±0.46	3.45±0.32	1.47±0.15	20.26±1.2	0.452±0.004
SP3	5.14±0.51	3.84±0.34	1.31±0.12	21.65±1.3	0.335±0.003
SP4	4.51±0.44	3.40±0.34	1.11±0.09	21.95±1.3	0.397±0.004
SP5	4.95±0.46	3.75±0.30	1.20±0.09	25.52±1.5	0.456±0.005
Beauregard	5.89±0.52	3.5±0.35	2.39±0.21	27.23±1.6	0.566±0.006
Abees	5.36±0.53	3.58±0.29	1.78±0.17	26.5±1.5	0.460±0.005

* TSS= total soluble sugars; TRS= total reducing sugars; *TNRS= total non-reducing sugars calculated by difference between (TSS-TRS).

The content of inulin (poly-fructose) ranged from 0.339 to 0.566 and the highest level was recorded in both tuber roots of orange-fleshed i.e. Beauregard followed by Abees. The white-fleshed clones (SP2, SP4, and SP5) contain less sugar and b-carotene and these results are consistent with those reported by [58, 59].

Starch content ranged from 19.78% in the purple-fleshed clone (SP1) to 27.23% in the dark orange-fleshed CV (Beauregard) with an average of 23.27 in all samples (Table 7). These values are within the ranges reported in the literature [60] From the results existed in Tables 6 and 7 it can be noticed that starch and inulin contents are correlated with DM contents in the tuber roots of orange-fleshed samples. These results are in good agreement with those reported by [61] who reported that root DM content, which is unpretentious, fast, and cheap to determine, can be used to select sweet potato clones with high extractable starch.

Nitrite concentration (NO_2^- ion mg/kg fwb)

Nitrite ion concentration in the tuber root of seven samples ranged from 7.4 to 9.1 NO_2^- mg/ion kg fwb for SP3 and Beauregard respectively (Fig. 1). All recorded values don't exceed 10 mg NO_2 ion/kg. These results indicated that consumption of tuber roots is safe because the recorded levels are within the save extent (10 mg/ion kg fwb) and don't cause any toxical effects. These results are in a good agreement with those reported by [18].

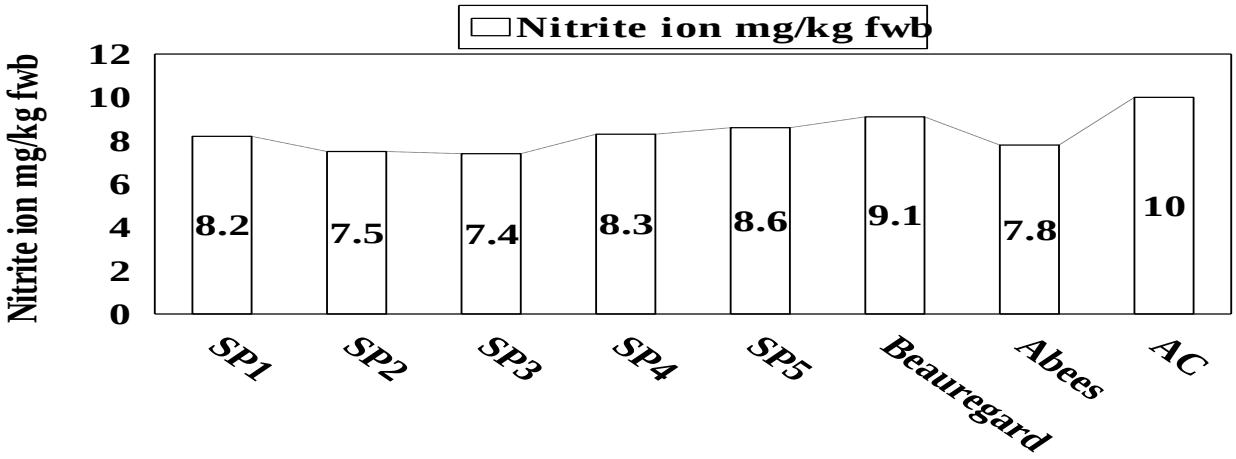

Fig. (1): Nitrite ion concentrations of tuber root of sweet potato clones

Nitrate concentrations (NO_3^- ion mg/kg fwb)

Nitrate concentrations in tuber roots varied from 169 in purple-fleshed (SP1) to 225 mg/kg fwb in dark orange-fleshed (Beauregard) and the white-fleshed clones (SP2 and SP5) contain 175 and 210 NO_3^- ion mg/kg fwb respectively (Fig. 2). Our results also confirmed that the highest nitrate ion concentration dosen't exceed 250 mg/kg fwb. Our results are in good agreement with those reported in the applied classification of [62, 63] sweet potato belongs to Division I; i.e. vegetables or crops containing low nitrate concentration (less than 250 mg/ion kg fwb).

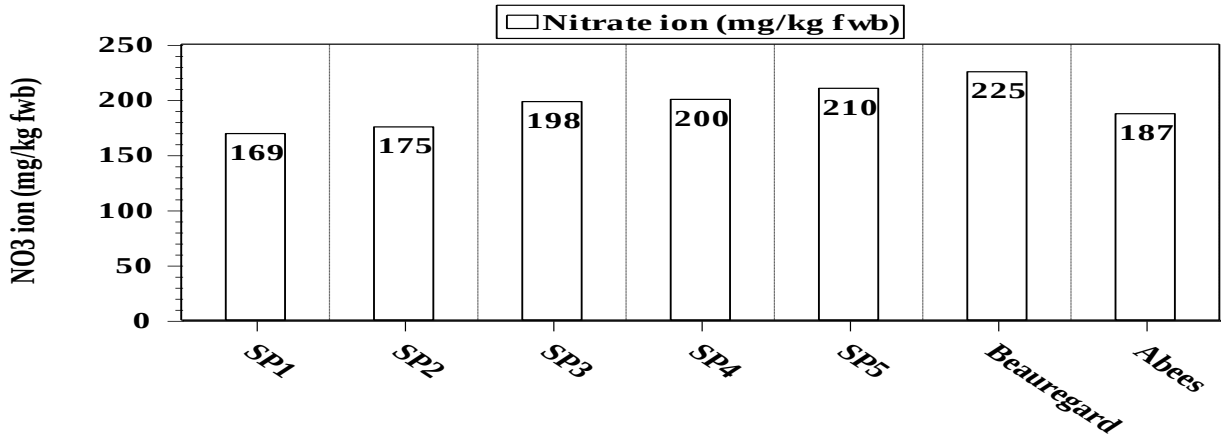

Fig. (2): Concentration of nitrate ion in tuber root of sweet potato clones

L-Ascorbic acid (Vitamin C) levels in SP samples

The concentrations of L-ascorbic acid (Vitamin C) in 7 tuber roots ranged from 18 for purple-fleshed (SP1) to 31 mg/100g fwb for dark orange-fleshed sweet potato (Beauregard). Abees samples ranked the second place (Fig. 3) and these results are lower than those reported by [64, 56, 18].

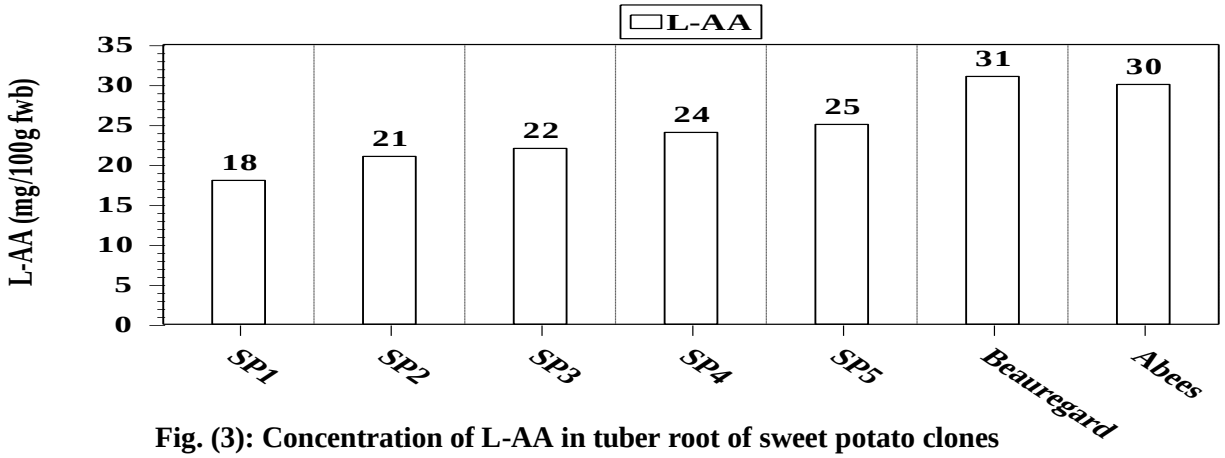

Fig. (3): Concentration of L-AA in tuber root of sweet potato clones

Composition and quality of five sweet potato cultivars were evaluated by [52] who found that vitamin C (L-ascorbic acid) content ranged between 16.13 and 23.42 mg. [50] found that the ascorbic acid (V.C) content in Mabrouka, Mansoura, Golden Bright, and 925 cvs. were 15.67, 15.89, 11.57, and 8.46 mg/100 gw, respectively. Sweet potato is quickly becoming an important supplementary staple and has great potentials to alleviate widespread malnutrition and poverty in developing countries. It is a good source of vitamin A and starch [3].

Through several publications, sweet potatoes contain bioactive carbohydrates (inulin, starch), lipids, proteins, anthocyanins, carotenoids, phenolic acids, and minerals represent versatile nutrients in different parts (tubers, leaves, stems, and stalks). Both the leaves and storage roots of sweet potato have a high nutritional value for the human diet. Next to starch which includes 60% of the dry matter (DM), leaves and storage roots are high in protein, dietary fiber, micronutrients (e.g. iron), vitamins (e.g. vitamin C) as well as bioactive compounds such as carotenoids and phenylpropanoids [65, 66]. The chemical properties of raw PSP mostly drop when processed into flour and when it was used in the products [67].

The unique composition of sweet potato contributes to their various health benefits, such as anti-oxidative, anti-inflammatory, anti-diabetic, antitumor, anti-obesity, antimicrobial, anti-aging effects.

3.4. Phytochemical content

Total phenolic acid and flavonoid contents

The amount of total phenolic acids and flavonoids differed significantly among the various sweet potato extracts (Table 8). The values of phenolic acid contents varied from 43.33 to 122.17 mg GAE/100 g dry weight of skin plant material and ranged from 25.42 to 58 mg GAE/100 g dry weight of the flesh as measured by Folin-Ciocalteau method. The flavonoid contents values ranged from 8.33 to 106.15 mg quercetin/100 g dry weight of skin plant material and ranged from 6.22 to 61.81 mg quercetin/100 g dry weight of flesh as measured by the $AlCl_3$ method. The methanol extract of skin SP2 was found to have the highest phenolic acid content value (122.17 mg GAE/100 g), followed by Beauregard (59.92 mg GAE/100 g) and sp4 extract (54.50 mg GAE/100 g). In the pulp, the methanol extract of SP4 was found to have the highest phenolic acid content value (58 mg GAE/100 g), followed by sp2 (52.33 mg GAE/100 g) and Beauregard (42.17 mg GAE/100 g). However, the highest value of flavonoid content was determined in the sp2 skin extract (106.15 mg quercetin/100 g), followed by Beauregard extract (62.48 mg quercetin/100 g) and sp4 extract (47.11 mg quercetin/100 g). From above results, we can see that sp2, Beauregard, and sp4 showed the highest total phenolic acid and total flavonoids contents among the various sweet potato genotype extracts.

This is genotype called high containing phenolic substances i.e. it is resistant against pathogen attacks. Many investigators correlated a relationship between secondary metabolites such as phenolic compounds and the potentiality of plants against pathogens attacks [68].

Free radical (DPPH) scavenging activity and Total antioxidant power of the extracts from sweet potato clones

Table (9) shows the order of free radical scavenging ability of the clone extracts was found to be in the skin extract as follows, Beauregard > Sp1 > Sp2 and in the flesh extracts as follows, Beauregard> Abees at high concentration of extract (50µg/ml).

Table 8. Total phenolic and flavonoid contents of the extracts from sweet potato samples.

Extracts/Fractions	Total phenolic content (mg/g)	Total flavonoid content (µg/g)
Skin		
Sp1	45.00±0.14	33.33±0.48
Sp2	122.17±2.18	106.15±0.61
Sp3	25.75±0.58	8.33±0.22
Sp4	54.50±0.87	47.11±1.56
Sp5	43.33±0.80	18.44±0.97
Beauregard	59.92±0.58	62.48±1.96
Abees	47.08±0.76	23.11±0.33
Flesh		
Sp1	36.67±0.76	17.30±0.06
Sp2	52.33±0.14	61.81±3.62
Sp3	25.42±0.14	6.22±0.11
Sp4	58.00±0.90	37.00±1.64
Sp5	34.67±0.38	13.52±3.32
Beauregard	42.17±0.58	25.26±0.89
Abees	38.92±0.63	21.37±0.50

* Total phenolic content expressed in mg Gallic acid equivalents/100 g dry weight of extract; Total flavonoids content expressed in mg Quercetin equivalents/100 g dry weight of extract; Each value is the mean ± SD of triplicate measurements. The data are presented as the mean ± SD of technical replicates (*n*=9).

Table 9. Percentage of DPPH inhibition and FRAP values for sweet potato extracts.

clones	**DPPH activity (%)** (50µg/ml)	**FRAP** (µM trolox)
Skin		
Sp1	19.64±1.15	881.10±23.52
Sp2	14.45±2.50	845.43±42.00
Sp3	3.54±1.64	456.77±2.08
Sp4	2.67±1.60	628.10±6.08
Sp5	1.95±0.09	576.43±8.33
Beauregard	20.78±0.66	922.43±10.69
Abees	7.68±1.06	666.10±4.00
Flesh		
Sp1	2.54±0.73	685.43±12.42
Sp2	4.71±0.34	630.10±7.81
Sp3	2.65±0.86	471.43±9.29
Sp4	2.54±0.66	667.43±13.05
Sp5	3.14±0.95	582.77±6.43
Beauregard	14.29±3.10	748.43±29.48
Abees	13.47±3.41	589.43±22.55

* The data are presented as the mean ± SD of technical replicates (n=9). FRAP expressed in µM Trolox/100 g dry weight.

However, Beauregard skin extract showed the highest FRAP value (922.43 µM trolox/100 g dry weight) and (748.43 µM trolox/100 g dry weight) in the flesh extract. The Beauregard extract possesses a significant free radical scavenging ability (20.78%) compare to the standard trolox (95.5%).

Total anthocyanins content

The methanol extract of Beauregard skin and flesh showed the highest total anthocyanin content 95.70 and 65.70 mg/L as equivalent of Cyanidin 6-O-glucoside, respectively Table (10).

Total anthocyanins in mg/L as equivalent of Cyanidin 6-O-glucoside in sweet potato is responsible for purple flesh color and makes the production of a white starch difficult. Hence white/ cream- and yellow-fleshed clones are the most suitable for the starch industry.. The sweet potato clones or cultivars with purple-fleshed contain many bioactive compounds and functional properties due to anthocyanins and other pigments that have antioxidant activities and high potentials [69]. Purple-fleshed sweet potato (*I. batatas* Lam.) has been reported to contain vital nutrients and bioactive compounds [67]. The antioxidant activity of the raw purple-fleshed sweet potato significantly rise after drying and dropped when the resulting flour was substituted in the products [67].

Table 10. Total anthocyanin content for sweet potato extracts.

Extracts/Fractions	Total Anthocyanin (mg/L)
Skin	
Sp1	26.70±5.80
Sp2	33.40±6.70
Sp3	5.00±0.17
Sp4	46.20±8.40
Sp5	95.70±10.7
Beauregard	73.50±2.30
Abees	76.30±2.76
Flesh	
Sp1	58.40±2.90
Sp2	31.70±2.13
Sp3	4.50±1.90
Sp4	36.70±1.70
Sp5	31.70±4.40
Beauregard	65.70±1.23
Abees	36.70±1.70

*** Total anthocyanin (mg/l as equivalent of cyanoidin 6-O-glucoside)**

In the present investigation, we have introduced five promising clones of sweet potato hoping that these clones help us to dissolve the lack of food problem and starch industry, whereas it contains starch ranged from 19 to 27.2%, and we also have determined 18 constituents to evaluate these local clones.

Many Asian and African countries use sweet potato in a solution to lack of foods problem as well as, the European countries use this crop in preparation of many balanced food meals after mixing it with some legumes. In common with other Convolvulaceae plants, sweet potatoes contain a number of naturally occurring compounds that give these plants high nutritive values. The most important classes of these compounds are anthocyanins (purple varieties), phenolic compounds, and total carotenoids (yellow varieties). Sweet potato (*Ipomoea batatas*) is a valuable medicinal food [65].

The introduction of new sweet potato clones for Egyptian markets are very useful, but there are challenges against these new candidates are instability property.

Preference index (PI)

We have applied a statistical function on which to choose the best sample of the items under study as well as arranging the samples in ascending order. From results of PI calculations, it can be noticed that established cultivar Beauregard (the dark orange-fleshed) tuber root ranked the first position with PI 69.22 followed by SP1 (purple-fleshed) with 51.9 and in the third position come Abees cultivar (yellow-fleshed) with PI 50.93 and the fourth position for the creamy-fleshed SP4 with PI 49.48. The results also indicate that the clones SP2 SP5 white-fleshed ranked the positions five and six. These results revealed that the colored-fleshed candidates are better than those with white-fleshed samples.

4. CONCLUSION

Results of preference index (PI) calculations it can be noticed that established cultivar Beauregard (the dark orange-fleshed) tuber root ranked the first position with PI 69.22 followed by SP1 (purple-fleshed) with 51.9, in the third position come Abees cultivar (yellow-fleshed) with PI 50.93, and the fourth position for the creamy-fleshed SP4 with PI 49.48.

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الملخص العربى

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يهدف العمل الحالي إلى تقييم محصول الطرز الوراثية للبطاطا المناسبة لتغذية الإنسان والحيوان ومقارنتها بالصنف المحلي ، بالإضافة إلى تحديد النشاط المضاد للأكسدة والمكونات النشطة في أصناف البطاطا المختلفة. مصر دولة نامية ذات كثافة سكانية عالية وتحتاج إلى غذاء لأكثر من 100 مليون فرد. نقدم في هذا البحث صنفين و 5 سلالات وراثية واعدة لتمد السكان بالغذاء. تمت التجارب الحقلية خلال العامين 2018 ، 2019 في المزرعة البحثية – محطة بحوث البساتين بسدس – مركز البحوث الزراعية – محافظة بني سويف – مصر. تم تقييم ستة وعشرين خاصية (8 قياسات خضرية) و 18 مكوناً كيميائياً. سجل أعلى القيم للعديد من القياسات الخضرية والمكونات الكيميائية الصنف Beauregard ذات اللحم البرتقالي داكن (مثل عدد الأفرع / نبات ، المحصول التسويقي الكلى (كجم / plot) ، المحصول الكلي ، النشا الكلي ، الأنولين ، المركبات الثانوية). ويتضح من النتائج ، يمكن استخدام Beauregard و Abees و SP1 و SP4 كمصدر للمركبات الفينولية والفلافونويدات الكلية (تركيز المركبات الفينولية الكلية 122.17 mg/g – 25.75 فى مستخلص القشور و 52.33 – 25.42 فى مستخلص اللحم بينما تركيز الفلافينويدات الكلية 106.15 µg/g – 8.33 فى مستخلص القشور و 61.81 µg/g – 6.22 فى مستخلص اللحم). ويمكن ترتيب الأصناف والسلالات محل الدراسة من حيث محتوى مستخلصات القشور من المركبات التى لها نشاط مضادات للأكسدة كما يلى Beauregard > Sp1 > Sp2 وفي مستخلصات اللحم على النحو التالي Beauregard > Abees بتركيز عالٍ من المستخلص (50 ميكروجرام / مل). ويتضح أيضاً أن مستخلص سلالة Beauregard أعطى أعلى قيمة FRAP (922.43 ميكرومتر ترولوكس / 100 جرام وزن جاف) و (748.43 ميكرو مولار ترولوكس / 100 جرام وزن جاف) في مستخلص اللحم. يمتلك مستخلص Beauregard قدرة كبيرة على إزالة الجذور الحرة (20.78٪) مقارنة مع ترولوكس القياسي (95.5٪). العينات قيد الدراسة ذات تفضيل غذائي كبير وأن البطاطا تحتوي على العديد من المركبات والأصباغ مثل الأنثوسيانين الذي يُنسب إليه تأثير مضادات الأكسدة والذي يعزز القيمة الغذائية لهذه العينات المرشحة بقوة في الدول النامية مثل مصر والدول الأفريقية. ونوصي بأستخدام البطاطا في التغذية اليومية ، مع تفضيل الأصناف الملونة التي تحتوي على أصباغ على غير الملونة.