Assessment of Chemical Composition and Bioactive Compounds in the Peel, Pulp and Whole Egyptian Eggplant Flour

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ABSTRACT: Eggplant (*Solanum melongena* L.) is one of the most popular common major vegetable crops worldwide. Eggplant flour prepared by to freeze drying is a highly desirable food ingredient. However, there are few data on the chemical composition of the parts (pulp and peel) of Egyptian eggplant flour. Therefore, the objective of this study was to determine the proximate chemical composition, minerals, amino acids and bioactive compounds in pulp, peel and whole Egyptian eggplant flour. The results of this investigation indicated that the peel of eggplant contained the highest amount of total dietary fiber (43.31%), insoluble dietary fiber (29.31%) and ash (6.20%) and lowest energy value (172.96 Kcal/100g dw) compared to the pulp and the whole eggplant flour. Eggplant peel contained highest amount of potassium, magnesium, iron and zinc compared with the pulp and the whole eggplant flour. Egyptian eggplant parts are rich source of amino acids (essential and non- essential). eighteen amino acids compounds were determined in eggplant parts with different concentrations. The results showed that the peel contained higher levels of total phenolic contents, total flavonoids and total anthocyanins than the pulp and the whole eggplant flour. Using HPLC, eighteen phenolic compounds were identified in the peel showed. 5- Caffeoylquinic acid (chlorogenic acid) was a major phenolic acid in eggplant peel representing 89.9% of total phenolic compounds. The highest levels flavonoids compounds in peel were quercetin-3-diglucoside, Myricetin-3-galactosid and Quercetin-3-rhamnoside. The major four eggplant skin anthocyanins characterized by HPLC-MS were delphinidin 3-rutinoside-5-galactoside (4.2%), delphinidin 3-rutinoside-5-glucoside (8.1%), delphinidin-3-glucoside (3.7%) and delphinidin-3- rutinoside (84%). Moreover, ascorbic acid and β-carotene contents were in higher amount in eggplant peel (17 mg per 100 g and 28 mg per 100 g, respectively) than in eggplant pulp. Eggplant flour, especially peels, could therefore be used as a good source of dietary fiber, minerals and phytonutrients and may be used as supplements in diets low in such compounds.

Key words: eggplant, peel, pulp, proximate chemical composition, mineral, amino acids, bioactive compounds , application.

INTRODUCTION

Recently, there has been an increment in consumer awareness toward bioactive components and their potential health benefits, leading to preference for foods which contain more functional bioactive compounds.

Consumption of fruits and vegetables rich on phytochemicals, particularly phenolic compounds, has been linked to reduce the risk of coronary heart diseases and certain forms of cancers and helpful in the reduction of blood cholesterol levels, in regulating high blood pressure and in weight reduction (Hung et al., 2004).

Eggplant (*Solanum melongena* L.), known as aubergine in Europe and brinjal in south Asia, is an economically important vegetable crop grown in many countries throughout the subtropics, tropics and Mediterranean area and their cultivars produce wide fruit diversity with different shapes, sizes and colours (Knapp *et al*., 2013, Mishra *et al*., 2013, Uthumporn *et al*., 2015 and San José *et al*., 2016).

In 2016, world production of eggplant was around to 60.19 million tons with China as main producer (29.5 million tons) followed by India (18.5 million tons), Europe (4.32 million tons), Egypt (3.2 million tons), Iran (2.85 million tons) and Turkey (1.82 million tons) (FAO, 2017).

Solanum species have been reported to reduce low density lipoprotein (LDL)/high density lipoprotein (HDL) ratio and increase HDL/LDL ratio in hypercholesterolemic rabbits (Odetola *et al*., 2004). They are ideal vegetables for people with increased serum lipid levels, high blood pressure and other ischemic heart diseases.

High crude fiber and low-fat contents of eggplants may be helpful in preventing such disorders as constipation, carcinoma of the colon and rectum, diverticulitis and atherosclerosis (Showemimo and Olarewaju, 2004). They may also partly account for the weight reduction (Odetola *et al*., 2004 and Edijala *et al*., 2005). The high fiber contents together with the low carbohydrate contents found in these vegetables are also good in the management of Diabetes mellitus (Bonsu *et al*., 2002).

Regarding nutritional value, eggplant has a very low caloric value and is considered among the healthiest vegetables for its high content of insoluble dietary fiber, vitamins, minerals and bioactive compounds (Plazas et al., 2013, Zaro *et al*., 2014, Ayaz *et al*., 2015, Caruso *et al*., 2017 and Gurbuz *et al*., 2018). Eggplant is ranked among the top 10 vegetables in terms of oxygen radical absorbance capacity (Cao *et al*., 1996, Jung *et al*., 2011 and Jiang *et al*., 2016).The bioactive properties of eggplant are mostly associated with high content in phenolic compounds, anthocyanins and flavonoids (Mennella *et al*., 2012 and Taher., 2017). Both phenolic acids and anthocyanins have multiple properties beneficial for human health (Braga et al., 2016). In addition, eggplant is distinguished for its content of flavonoids in peel with high amounts of the anthocyanin (Wu and Prior, 2005 and Koponen *et al*., 2007) and also is recognized for high levels of phenolic acids in the peel and flesh (Winter and Herrmann, 1986 and Whitaker and Stommel, 2003).

Recently, Gurbuz *et al.* (2018) published that the peel of Turkish eggplant contain high amount of dietary fiber and phytonutrients as total polyphenol content, total flavonoid content and total anthocyanidins. Eggplant cultivars with dark purple skin receive considerably more attention for being much richer in anthocyanins, with much higher concentrations as compared to grapes (Wu and Prior., 2005 and Guine *et al*., 2018).

The health and nutritional benefits of Egyptian eggplants have led to their increased demand and hence production. However, increased production is accompanied by increase in postharvest losses due to their perishable nature. Furthermore, perishable commodities such as Egyptian eggplants are sensitive to chilling injury (Yahia *et al*., 2004). Due to the relatively short post-harvest life in fresh form, vegetables can be converted to shelf stable forms through processing (Vincente *et al*., 2014).

One of the most commonly used processing methods is drying. Drying may cause damage to the inherent nutrients and bioactive compounds depending on the drying method and treatment conditions. Therefore, the choice of the drying method and optimization of the drying process are important for bioactive compound retention (Akdaş and Başlar, 2015). Several studies have described the drying characteristics of various vegetable products such as tomato and eggplant (Mwende *et al*., 2018 and Mbondo *et al*., 2018). However, information on drying of Egyptian eggplant is insufficient. To the best of our knowledge, no studies have been devoted to determine the effect of different drying methods on the retention of bioactive compounds in Egyptian eggplant as described in first part of this study (data are not included).

One way to avoid losses and capitalize on the nutritional characteristics of eggplant is processing it into flour. Eggplant flour is a highly desirable food ingredient to enrich the diet; however, there are few data on its chemical composition (Scorsatto *et al*., 2017).

Therefore, the objective of this work was to determine the proximate chemical composition, minerals, amino acids and bioactive compounds in pulp, peel and whole Egyptian black eggplant flour.

MATERIALS AND METHODS

1. Materials and Chemicals

Fresh eggplant (*Solanum melongena* L.) var. Black Beauty used in this study was purchased from the local Market, Alexandria, Egypt in May 2017. The tubers were washed by tap water and the peels were separated manually with a sharp knife (Taous, 2016). Pulps, peels and whole eggplants were freeze dried for 72 h with a lyophilizer (Freeze Dryer FD (LOUW KOELTECHNIEK BVBA) with a standard program as described by Zaro *et al.* (2015). Next, dried samples were ground with grinder (Stainless Steel Vertical Type- High Speed Grinding and Pulverizing Machine, Model RT-34, WHL Machinery, Selangor, Malaysia) and further sieved through 250 µm mesh sieve. Flour was then kept and sealed in polypropylene plastic bag and subsequently in airtight container and stored at -18 °C prior to use. All chemicals, solvents and standards were of analytical grade and purchased from Sigma (St. Louis, MO, USA).

2.Methods

1. Proximate analysis and energy value

Protein, Ether extract, Nitrogen Free Extract (NFE), ash, total dietary fiber, soluble dietary fiber and insoluble dietary fiber were evaluated in the different samples of pulp, peel and whole eggplant flour as described by AOAC (2006). Nitrogen Free Extract (NFE) was calculated by difference. Energy values (Kcal/100g) were calculated as reported by Greenfield and Southgate (1992) applying the factors, 4,9 and 4 for each g of protein, lipids and carbohydrate, respectively, according to the following equation:
Energy = 4 × (g protein + g carbohydrate) + 9 × (g fat).

2. Mineral composition

Mineral content of the sample was assayed by modified AOAC (2006). Two g of the pulverized sample was transferred into a pre-weighed crucible and placed in a muffle furnace at 550 °C for about 6 h by which time the sample had completely ashed. The resulting ash was dissolved in 20 mL HNO3 (10 %) solution and the solution was boiled on a hotplate for 15 min, filtered and made up to mark with distilled water in a 100 mL volumetric flask. This ash solution was then used for mineral analysis. Reagent blank was prepared by boiling 20 mL HNO3 (10 %) solution on a hotplate for 15 min, filtered and made up to mark with distilled water in a 100 ml volumetric flask as described by Uzu *et al*. (2017). eight minerals (K, Mg, Ca Na, Fe, Zn, Cu, and selenium) were determined in the ash solution. The blank solution was also determined with an Atomic Absorption Spectrophotometer (Buck Scientific Model 2010 VGP). The equipment was calibrated with 100 mg/L of the standard solution of each element determined while P was determined with the use of a UV-visible Spectrophotometer (LabMedSPECTROSC). The results are mean of three replicates.

3. Amino acids

Amino acids were determined according to the Official Method of the AOAC (2006). A sample of 2g ± 0.001g was weighed into a pre-dried and tarred dish. Then the sample was placed into an oven at 60±1°C for four h as described by Bernardo and Sagum (2016). The covered sample was transferred to desiccator and cooled to room temperature, after that the sample was digested with 30 ml of 6 M HCL for 24 h at 110°C and was digested again with 30 ml of 4.2 M NaOH for 24 h at 110°C after the addition 25 ml of methanol (HPLC grade) for each sample. The extract was then filtered by Whatman filter paper; No.42 into a round bottom flask before injection into the HPLC. Finally, the volume was made up to 5ml and then injected to HPLC (Gilson), using an ion exclusion column (Nucleogel Ion 3exclusion column (Nucleogel Ion 300 OA; 300 × 7.7 mm), in conjunction with a column heating device at 30 °C.

4. Extraction procedure

Ten g of each flour sample was extracted with 400 mL of ethanol for 24 h at room temperature as described by Nayanathara *et al*. (2016). After shaking at 100 rpm in a shaker (SHWB-30, Woori Science Co., Seoul, Korea) for overnight at room temperature, the solvent extracts were filtered through Whatman No.1 filter paper. The filtrates were concentrated to dryness under reduced pressure on a rotary evaporator (Eyela N-1000, Tokyo Rikakikai Co., Tokyo, Japan) at 37°C.It was then filtered through Whatman filter paper No 4. All samples were placed in a glass bottle with saturation of nitrogen gas and stored at 4°C until used for further bioactive compounds analysis.

5.Total phenolic content

Phenolics were determined by a Folin–Ciocalteu assay as described by Singleton and Rossi (1965). The extract solution (1 ml) was mixed with Folin–Ciocalteu reagent (5 ml, previously diluted with water 1:10, v/v) and sodium carbonate (75 g/l, 4 ml). The tubes were vortex mixed for 15 s and allowed to stand for 30 min at 40±ºC for colour development. Absorbance was then measured at 765 nm. Gallic acid was used to obtain the standard curve

(0.0094–0.15 mg/ml), and the results were expressed as mg of gallic acid equivalents (GAE) per g of dry weight (dw).

6. Total flavonoids

Total flavonoids were determined as described by Nayanathara *et al*. (2016). The extract sample concentrated at 2.5 mg/ml (0.5 ml) was mixed with distilled water (2 ml) and $NaNO_2$ solution (5%, 0.15 ml). After 6 min, $AlCl_3$ solution (10%, 0.15 ml) was added and allowed to stand further for 6 min. NaOH solution (4%, 2 ml) was added to the mixture, followed by distilled water until a final volume of 5 ml was obtained. The mixture was properly mixed and allowed to stand for 15 min. The intensity of pink colour was measured at 510 nm. (+)-Catechin was used to calculate the standard curve (0.015–1.0 mM) and the results were expressed as mg of (+)-catechin equivalents (CE) per g of dry weight (dw).

7. Identification of phenolic and flavonoid compounds Instrument conditions

Phenolics were identified by high performance liquid chromatography coupled with mass spectrometry (HPLC/MS). The HPLC system (Shimadzu Co., 10VP Series, Columbia, MD, USA) employed a Hypersil Gold C_{18} (3 μm particle size; 150 mm length × 3.0 mm ID; Thermo Electron Co., Bellefonte, PA). Five μl of the extract was injected onto the column and a gradient elution was used for separations as described by Singh *et al*. (2017). Identified phenolics were quantified using an HPLC (Waters, Milford, MA, USA) equipped with a Waters 996 Photodiode Array Detector (PDA). Quantification of all the phenolic compounds was based on a standard curve prepared with 5-caffeoylquinic acid. Myricetin-3-galactoside, quercetin-3-glucoside, and quercetin-3- rhamnoside were quantified using the corresponding authentic standard for each compound. For all standards and extracts, 40 μl were injected and separated using the aforementioned column and solvent system, but at a flow rate of 1 ml/min. PDA was monitored at two wavelengths (325 nm for phenolic compounds and 366 nm for flavonols) and two spectral scans were continuously collected from 200 to 600 nm. The data acquisition and processing were performed by Waters EmpowerTM Chromatography Software (Waters, Milford, MA, USA).

Calibration curves

All standard samples were prepared by adding known amounts of 5-caffeoylquinic acid, myricetin-3-galactoside, quercetin-3-galactoside, and quercetin- 3-rhamnoside of six concentrates in 1 ml of methanol.

Recovery studies

Samples were spiked with known amounts of 5-caffeoylquinic acid, quercetin- 3-galactoside, quercetin-3-rhmanoside, andmyricetin-3-galactoside (200 and 500 ng/ml in triplicates and then extracted and quantified as described above.

8. Total anthocyanins

Anthocyanin contents were determined for eggplant flour samples based on cyanidin-3-glucoside equivalent (CGEs) through a pH differential method adapted from Nayanathara *et al*. (2016). In brief, a 0.025 M-solution of KCl was acidified by HCL (to reach pH = 1), while a 0.4 M-solution of $NaCH_3CO_2$ was adjusted to pH 4.5 by CH_3CO_2H. Then, 100 µL of each eggplant flour extract was mixed in methanol (at 10 mg/mL) with 900 µL of the KCl solution and the same procedure was performed with the $NaCH_3CO_2$ solution. Amounts of hundred µL of the mixture were then loaded into each well of the 96-well plate. Absorbance was read by the spectrophotometer at two levels; 510 and 700 nm and calculations were made for total anthocyanins using the following equation (mg/100 g dw):

$$A \times MW \times DF \times 10^3/\varepsilon x1$$

Where A = (A_{520} nm - A_{700} nm), MW (molecular weight) = 449.2 g/mol for cyanidin- 3-glucoside; DF = dilution factor; l = path-length in cm; ε = 26 900 molar extinction coefficients, in Lxmolxcm, for cyd-3-glu; and 10^3 = factor for conversion from g to mg. Final values were then expressed as mg of CGEs per 100 g of dw.

9. Identification of Anthocyanins

The same aforementioned HPLC-MS instrument and column were used for anthocyanin analysis as described by Singh *et al*. (2017). Eggplant skin extract (5 µL) and anthocyanins standards were eluted with a gradient of 5% formic acid in water (solvent A) and 100% methanol (solvent B) at a flow rate of 0.3 mL/min. Following gradient was used: 0 min, 95% A; 2 min, 80% A; 10 min, 80% A; 15 min, 70% A; held at 35 min, 70% A, 35 min, 60% A; held at 50 min, 60% A. Five min of equilibration at 95% A was performed before and after each injection. Conditions for mass spectral analysis in the positive ion mode included a capillary voltage of 4200 V, a nebulizing gas of 7.0 psi and a temperature of 350˚C.

10. Ascorbic acid

For ascorbic acid, standard ascorbic acid solution (5 mL L-ascorbic acid in 3% phosphoric acid) was added to 5 mL of meta-phosphoric acid. A microburette was filled with dye (2,6-dichlorophenol indophenol), and the samples were titrated with the dye solution to a pink colour, which persisted for 15 s. The dye factor (mg of ascorbic acid per ml of dye using formula: 0.5/titrate) was determined. A sample was prepared by taking 10 g of sample grounded in metaphosphoric acid, and the volume was increased up to 100 mL. It was titrated after filtration until a pink colour appeared (Guine *et al.,* 2018). The amount of ascorbic acid was calculated with the use of the following equation:

mg of ascorbic acid per 100 g sample dry weight =

$$\frac{\text{Titrate} \times \text{Dye factor} \times \text{Vol. made}}{\text{Aliquot of extract} \times \text{wt. of sample}} \times 100$$

11. β- Carotene

For β-carotene determination, the extract (100 mg) was vigorously shaken with 10 ml of acetone– hexane mixture (4:6 v/v) for 1 min and filtered through Whatman No. 4 filter paper (Mbondo *et al.,* 2018). The absorbance of the filtrate was measured at 453, 505 and 663 nm. Content of β-carotene was calculated according to the following equations:

β-carotene (mg/ 100 ml) = 0.216 × A663 - 0.304 × A505 + 0.452 × A453

12. Statistical analysis

The results of the present study were represented as mean values ± SE. One-way analysis of variance (ANOVA) was performed and significant differences between mean values were determined by Duncan test at a level of significance of $p \leq 0.05$. Statistical analysis was conducted using SPSS (Statistical Package for Social Science), SAS (1996).

RESULTS AND DISCUSSION

1. Proximate chemical composition of Egyptian eggplant flour

The results of the proximate chemical composition of pulp, peel and whole eggplant flour are shown in Table (1). The results revealed that fresh eggplants generally had high moisture content (93.60%) which makes them prone to quick deterioration, hence they are classed amongst perishable fruits (Howarth *et al*., 2001). The high moisture content makes the eggplant to be of high nutritional benefits to people suffering from dehydration and the skin helps to keep the fruit fresh to meet market freshness demand.

The moisture content of all parts of eggplant flour was in the range of 9.15 - 9.45%. There were no significant differences in moisture content between whole eggplant flour, pulp and peel. Moisture content in this study was found to be higher than the result of moisture reported by Hussain *et al*. (2011). The pulp recorded the highest amount of protein, which was 17.82% on dry weight, whereas the peel had the lowest amount of protein, which was 12.25%.The results of protein contents obtained from all parts of eggplant are higher compared to the work reported by Hussain *et al*. (2011) who found that protein contents varied from 9.7 to 15.8 %. They referred that the eggplant cultivars may therefore not be an ideal plant for protein supplementation.

Previous studies on protein content of eggplant showed that Mexican eggplant contained 12.4% as described by Sanchez-Castillo *et al*. (1999), while a study carried out by Pak (2000) found 11.3% in eggplants collected from Chile. Takeyama *et al*. (2002) reported a protein content of around 12.4% in a Japanese cultivar, and Rehman *et al*. (2003) found a value of 11.5% of protein in eggplants cultivated in Pakistan.

This may be due to the different fertilizers used to cultivate the eggplants. According to Mut *et al*. (2010), the addition of animal manure as a fertilizer to soil can increase the protein content of plants.
Although the protein contents of eggplants are low, they are still useful in the repair of worn out tissues in the body.

For dietary fiber analysis, peel of eggplant contained the highest amount of total dietary fiber (43.31%) and insoluble dietary fiber (29.31%) compared to other parts. Insoluble dietary fiber showed about two fold of soluble dietary fibers in all eggplant parts. These results are in agreements with the results of Scorsatto *et al*. (2017). They referred that even though fibers do not supply nutrients to the body, they are essential in the diet. They promote a number of health benefits in view of which the use of eggplant flour is considered a potential food ingredient. Insoluble fiber helps promote regularity and a healthy digestive system. Dietary fibers in all the parts of eggplant flours were higher compared to wheat flour (Uthumporn *et al*., 2015). Therefore, it is believed that eggplant flour can be used as a functional ingredient and be incorporated to produce functional or fiber fortified food.

An average intake of 25 g per day of dietary fiber in adults is recommended by the American Dietetic Association (based on a 2000 kcal per day diet) (Marlett *et al*., 2002). Based on this value, an intake of 100 g per day of the eggplant types analyzed in this study could account for 6.5 to 16 % of the recommended daily intake (RDI).

For fat content (ether extract), the results obtained fell on a range of 1.52 - 1.85% in different parts of freeze-dried eggplant flour. These results are in accordance with the work by Lawande and Chavan (1998). They reported that fat content for eggplant ranged between 1.33-2.20%. The pulp showed the highest fat content (1.85%) while the peel had the lowest fat content (1.52%). The results obtained indicated that different parts of eggplant had different fat content, which is in agreement with the previous study by Nisha *et al*. (2009).

The highest ash content was obtained from peel (6.20%) and the lowest content was obtained from pulp (4.22%). Ash content of eggplant reported by Hussain *et al*. (2011) was 6.9%, which is comparable to the ash content obtained in this study. Ash content represents the mineral contents in food because ash is the inorganic residues left over after complete ignition or oxidation of organic compounds in food (Harbers and Nielsen, 2003). Calcium, magnesium, phosphorus, potassium, iron and sodium were some of the major minerals that contained in eggplant. Savvas and Lenz (1996) also found that eggplant provide relevant quantities of some minerals such as phosphorus, potassium, calcium and magnesium. The pulp showed the highest Nitrogen Free Extract (NFE) content, whereas the peel had the lowest carbohydrate content, which was 33.78 and 27.57%, respectively. The results of the present investigation are similar to the carbohydrate content obtained by Hussain *et al*. (2011). The low carbohydrate level of eggplant cultivars makes them good for diabetic patients and individuals watching their weight (Agoreyo *et al*., 2012).

This reasonably good amount of carbohydrate and moderate amount of crude fiber and low crude proteins make them good source of raw material for food industries (Edem *et al*., 2009). Moreover, the high crude fiber, low fat and low dry matter of the eggplants may be helpful in preventing diseases such as constipation, carcinoma of the colon and rectum and atherosclerosis (Showemimo and Olarewaju, 2004).Pulp showed higher energy content (223.05 Kcal/100g dw) than whole fruit (206.66 Kcal/100g dw) and peel showed lowest energy value (172.96 Kcal/100g dw). Ossamulu *et al*. (2014) found that energy values varied from 22.90 to 34.02 Kcal/100g on fresh weight for four eggplant cultivars. The moisture contents of four cultivars were from 89 to 90%. The low energy content of the eggplant cultivars may be very helpful in weight management. To lose weight, fewer calories must be taken than what is expended (Bell *et al*., 1998).

Water and fiber in foods increase volume of the food and thereby reduce its energy density. It has been shown that in their natural state, fruits and vegetables have high water and fiber content and are low in calories and energy density (Grunwald *et al*., 2001).

In conclusion, the results showed that eggplant flour had high nutritional value and it is a better source for protein, crude fiber and ash. Eggplant flour contained lower amount of moisture and carbohydrate. There is an inverse relationship between moisture content and storage stability of flour, as lower the moisture content of flour, the better its storage stability. An investigation also found that flour with the lowest moisture content had the maximum resistance against fungal growth and pest infestation during storage. Flour having moisture content of 9% to 10% is suitable for extended shelf life (Nasir *et al*., 2003). Hence, it was believed that eggplant flour produced could have greater shelf life and higher storage stability compared to wheat flour due to the lower moisture content.

When compared with wheat flour, it was observed that Egyptian eggplant flour featured higher levels of protein and total dietary fiber whereas carbohydrate content was lower. In this way, the high dietary fiber content, the high-water absorption capacity, and the ease of grinding make eggplant flour a good alternative to be mixed with wheat flour. This mixed flour can be used in the preparation of bakery products (cookies, breads, cakes, and pasta), expanding the number of products to supplement the daily fiber intake (Scorsatto *et al*. (2017).

Table (1). Proximate chemical composition and energy value of Egyptian eggplant flour

	Eggplant flour		
Component (%)	**Whole fruit**	**Pulp**	**Peel**
Moisture (Dry matter)	9.25 ± 0.42^{a}	9.45 ± 0.48^{a}	9.15 ± 0.40^{a}
Crude Protein	15.85 ± 0.66^{c}	17.82 ± 0.62^{d}	12.25 ± 0.56^{b}
Total dietary fiber	36.64 ± 1.88^{e}	32.76 ± 1.52^{e}	43.62 ± 0.51^{f}
Soluble dietary fiber	11.82 ± 0.48^{b}	9.88 ± 0.42^{a}	14.31 ± 0.51^{c}
Insoluble dietary fiber	24.82 ± 1.08^{g}	22.88 ± 0.82^{g}	29.31 ± 0.51^{h}
Ether extract	1.66 ± 0.22^{i}	1.85 ± 0.25^{i}	1.52 ± 0.26^{i}
Ash	5.34 ± 0.38^{j}	4.22 ± 0.23^{j}	6.20 ± 0.52^{j}
Nitrogen Free Extract (NFE)	31. 26 ± 1.62^{e}	33.9 ± 1.38^{e}	27.26 ± 1.52^{h}
Energy (Kcal/100g)	206.66	223.05	172.96

All values are expressed as means± SD on dry weight basis of triplicates, n=3.
Means in raw sharing the same superscript letter are not significantly different ($p\leq 0.05$)

2. Minerals in Egyptian eggplant flour

The results of minerals in different parts of Egyptian eggplant flour (*Solanum melongena* L.) var. Black Beauty are presented in Table (2). In general, eggplants parts contained considerably high amounts of minerals, The most abundant elements were potassium (23801.8 – 27889.6 mg/kg dw), magnesium (2011.2-2252.2 mg/kg dw), iron (201.6-378.2 mg/kg dw), phosphorus (220.4-301.3 mg/kg dw), and calcium (160.0-300.8 mg/kg dw) followed by selenium (69.1-103.1 mg/kg dw), sodium (36.2-61.2 mg/kg dw), zinc (20.6-63.1 mg/kg dw) and copper (10.7-74.0 mg/kg dw). These results are in a good agreement with the previous research investigations (Raigón *et al*., 2008, Chinedu *et al*., 2011 and Arivalagan *et al*., 2013). The potassium contents of different eggplant parts were higher than the level of other minerals. Eggplant peel contained the highest amount of potassium, magnesium, iron and zinc compared with both the pulp and the whole fruit of eggplant. These results are agreed with Taous (2016) who found that Algerian eggplant peel contained highest amount of potassium (27889.61 ppm), magnesium (2010.0 ppm), iron (145.0 ppm) and zinc (17.0 ppm). Amadi *et al.* (2013) mentioned that potassium was the highest elements (23810 mg/kg) in Nigerian ripe eggplants. On the other hand, Ayaz *et al*. (2015) found that the mineral concentrations varied significantly ($P<0.05$) among the studied Turkish eggplant cultivars. The minimum and maximum levels were very similar for Cu, Zn, Fe and Mn, while the range was much higher for the other five minerals, P, Ca, Mg, K and Na. The highest K concentration was detected in Kemer variety (31715.6), followed by Topan variety (15562.0 ppm). The second most abundant element of the eggplants was Mg (2833.4 ppm), phosphorus (978.5 ppm) and Ca (888.9 ppm), respectively.

Recently, Uzu *et al* (2017) studied mineral content of ripe and unripe African eggplant fruit. They published that potassium was the most prominent mineral element in African eggplant (95258 mg/kg dw) followed by magnesium (5950 mg/kg dw), zinc (29.38 mg/kg dw), phosphorus (124.5 mg/kg dw) and iron (112.5 mg/kg dw). Variation of minerals among plants may be due to differences in geographical locations, soil type, and intensity of fertilization, plant species and seasons of cultivation (Ossamulu *et al*., 2014).

Eggplants could therefore be a good source of calcium and iron and this study suggests that eggplant could be a good source of potassium; making it an important food for people suffering from hypokalemia and other potassium deficiency related diseases so that it may be used as supplements in diets low in such minerals.

Sodium was observed to be lower than potassium in both ripe and unripe *S. aethiopicum* fruit exocarps (Chandra, 1990). The low sodium concentration is nutritionally ideal for hypertensive patients since a high level of sodium in-take is associated with high blood pressure. On the other hand, high intake of dietary potassium has been reported beneficial in relation to blood pressure control (Amadi *et al*., 2013). Na, Mg, Ca and Zn have been described as the mostly required mineral elements for the proper functioning of the living cells and their deficiencies have been associated with disrupted enzymatic activities and poor electrolyte balance of blood fluids (Uzu *et al*., 2017). Selenium content in this study showed significant values from 57.3 to 103.1 mg/kg. Selenium as an antioxidant helps prevent oxidative stress, inflammation and DNA repair. It is also a constituent of glutathione peroxidase which is a major scavenger of H_2O_2 (Achikanu *et al*., 2013).

Table (2). Mineral content in Egyptian eggplant flour

Minerals (mg/kg dw)	Eggplant flour Whole fruit	Pulp	Peel	FAO Pattern*
Potassium	23801.8 ± 280a	26014.4 ± 256b	27889.6 ± 328c	3500
Magnesium	2011.2 ± 185d	2105.5 ± 198e	2252.2 ± 189f	350
Calcium	160.0 ± 86g	205.5 ± 94h	300.8 ± 118i	1000
Sodium	61.2 ± 22j	73.2 ± 38k	36.2 ± 21l	2400
Iron	201.6 ± 81h	260.1 ± 86m	378.2 ± 144n	15
Zinc	20.6 ± 21o	37.3 ± 25l	63.1 ± 28 j	15
Phosphorus	220.4 ± 83p	241.8 ± 86q	301.3 ±114i	1000
Copper	10.7 ± 18r	34.1 ± 22l	74.0 ± 41k	2
Selenium	69.1 ± 38 k	57.3 ± 31s	103.1 ± 31t	35

All values are expressed as means± SD on dry weight basis of triplicates, n=3
Means in row sharing the same superscript letter are not significantly different ($p<0.05$). *FAO/WHO/UNU (1985).
On comparison with FAO (1985) mineral reference pattern, the three parts of Egyptian eggplant flour possesses higher quantity of all minerals except calcium, sodium and phosphorus

3. Amino acid composition in Egyptian eggplant flour

Egyptian eggplant parts are a rich source of amino acids (essential and non- essential). Seventeen of amino acid compounds were found in eggplant parts in different ratios (Table 3). The most essential amino acids found in whole eggplant, pulp and peel in the highest amounts were leucine (48.52, 55.14 and 41.58 g/kg protein, respectively), valine acid (42.10, 46.11 and 33.12 g/kg protein, respectively), phenylalanine (28.42,32.12 and 21.38 g/kg protein, respectively) and isoleucine (22.25, 31.32 and 17.55 g/kg protein, respectively). Total essential amino acids (TEAA) for whole eggplant, pulp and peel represented 207.31 ± 8.82, 238.21 ± 9.61 and 157.88 ± 6.52 g/kg protein, respectively.

The most non-essential amino acids found in whole eggplant, pulp and peel were glutamic acid (61.18, 65.15 and 45.14 g/kg protein, respectively), aspartic acid (40.72, 48.12 and 28.14 g/kg protein, respectively), arginine (39.27, 38.88 and 31.50 g/kg protein, respectively), alanine (24.41, 26.22 and 17.88 g/kg protein, respectively) and glycine (20.11, 15.45 and 11.26 g/kg protein, respectively). Total non-essential amino acids for whole eggplant, pulp and peel represented 216.42 ± 6.98, 224.81 ± 6.92 and 154.84 ± 6.22 g/kg protein, respectively.

These results are agreed with the results of Adeyeye and Adanlawo (2011) who determined amino acids in different species of eggplant fruits. They found that the total essential amino acid ranged from 208 g/ kg to 288 g/ kg crude protein. Leucine was the highest essential amino acid ranged from 57-66 g/ kg followed by valine (41.6), lysine (37.8) and isoleucine (31.7 g/ kg). Glutamic acid (97.0 g/ kg) and aspartic acid (69.5 g/ kg) had the high concentrations among non-essential amino acids.The investigation of Amadi *et al*. (2013) referred that eggplant (*Solanum melongena* L.) contained high amounts of amino acids as leucine, arginine, phenylalanine and alanine.

On comparison with FAO (1985) essential amino acids (EAAs) reference pattern, the three parts of Egyptian eggplant flour possess high quantity of all essential amino acids.

Table (3). Amino acids in Egyptian eggplant flour

Amino acid pattern (g / kg dw)	Eggplant flour			
	Whole fruit	Pulp	Peel	FAO Pattern*
Essential Amino Acids (EAA)				
Threonine	11.20 ± 0.56[a]	12.66 ± 0.72[a]	8.12 ± 0.46[b]	3.4
Valine	42.10 ± 2.28[c]	46.11 ± 2.58[c]	33.12 ± 1.06[d]	3.5
Cystine	6.12 ± 0.22[e]	6.88 ± 0.24[e]	4.14 ± 0.23[f]	
Methionine	4.14 ± 0.24[f]	4.48 ± 0.26[f]	3.11 ± 0.14[g]	2.5
Isoleucine	22.25 ± 1.12[h]	31.32 ± 1.08[d]	17.55 ± 0.62[i]	2.8
Leucine	48.52 ± 2.68[j]	55.14 ± 3.96[k]	41.58 ± 2.06[c]	6.6
Tyrosine	20.12 ± 0.75[l]	24.14 ± 1.41[m]	14.43 ± 0.67[n]	
Phenylalanine	28.42 ± 1.27[o]	32.12 ± 1.12[d]	21.38 ± 0.54[l]	6.3
Lysine	12.62 ± 0.61[a]	12.89 ± 0.44[a]	8.12 ± 0.32[b]	5.8
Histidine	11.82 ± 0.52[a]	12.47 ± 0.42[a]	6.33 ± 0.22[e]	1.9
Tryptophan	1.31 ± 0.11[t]	1.42 ± 0.11[t]	1.22 ± 0.11[t]	1.1
Total Essential Amino Acids (TEAA)	**207.31 ± 8.82**[q]	**238.21 ± 9.61**[r]	**157.88 ± 6.52**[s]	
Non-Essential Amino Acids (NEAA)				
Glutamic acid	61.18 ± 3.28[p]	65.15 ± 3.56[p]	45.14 ± 2.48[c]	
Aspartic acid	40.72 ± 2.08[c]	48.12 ± 2.82[j]	28.14 ± 1.55[o]	
Serine	20.31 ± 0.68[l]	21.55 ± 0.66[l]	14.68 ± 0.56[n]	
Proline	10.42 ± 0.52[a]	9.44 ± 0.48[b]	6.24 ± 0.38[e]	
Alanine	24.41 ± 1.38[m]	26.22 ± 1.54[m]	17.88 ± 2.58[i]	
Glycine	20.11 ± 0.54[l]	15.45 ± 0.60[n]	11.26 ± 0.48[a]	
Arginine	39.27 ± 1.88[c]	38.88 ± 1.69[c]	31.50 ± 1.18[d]	
Total Non-Essential Amino Acids (TNEAA)	**216.42 ± 6.98**[q]	**224.81 ± 6.92**[r]	**154.84 ± 6.22**[s]	

All values are expressed as means± SD on dry weight basis of triplicates, n=3
Means in row sharing the same superscript letter are not significantly different ($p<0.05$).
*FAO/WHO/UNU (1985)

4. Some bioactive compounds in Egyptian eggplant flour

1. Total phenolic contents in eggplant flour

A greater level of total phenolic compounds was found in the peel being 3838 mgGAE/100g dw while the pulp contained 926 mg GAE/100g dw. On the other hand whole eggplant contained 1815 mgGAE/100g dw (Table 4). These results are in agreement with the results of Boubekri *et al*. (2013) who found that the peel of Algerian dark-purple eggplant contained (3743 mg GA/ 100 g dw) and also agreed with results of Uthumporn *et al*. (2016) who found that Indonesian purple round eggplant contained 1918.1 mg GA/ 100 g dw .Also The results obtained in the present study agreed with those reported with Djouadi *et al*. (2016) who recorded that the total amounts of phenolic values of different parts of Algerian dark-purple eggplant were 2003.5, 2413.4 and 37487.7 mg GA/ 100 g dw for whole eggplant, pulp and peel, respectively.

On the other hand, the results obtained in the present study are higher than recently obtained by Basudan (2018) who reported that the highest levels of total phenolics were recorded in Egyptian black eggplant (1600 mg GAE/100g dw) compared with white eggplant (1200 mg GAE /100g dw). These differences could be due to growing conditions of eggplants. Huang *et al*. (2004) and Ji *et al*. (2011) found that eggplant peel had higher phenolic compounds content, and it was about two to four times greater than in eggplant pulp.Different studies have shown that most phenolic compounds are concentrated in the skin surface of fruits (Dadalı *et al*., 2007 and Jung et al., 2011).The identification and quantification of the different phenolic phytochemicals in peel showed 18 compounds (Table 5 and Fig 1). 5-Caffeoylquinic acid was the major phenolic acid in eggplant peel representing 89.9% of total phenolic compounds. These results are in agreement with the results of Luthria and Mukhopadhyay (2006) and Singh *et al*. (2009).

Recently, Singh *et al*. (2017) identified sixteen different phenolic acids from eggplant skin. Among them, 5-caffeoylquinic acid, 3-5-dicaffeoylquinic acid, N- caffeoyl putrescine and 3-acetyl-5-caffeoylquinic acid were the most abundant phenolic acids in the analyzed eggplant skins. The health benefits of the natural phenolic components present in vegetables are mainly attributed to their antioxidant activity. The high percentage of phenolic antioxidant components as observed in the present work are consistent in ranking eggplant as one of the top ten oxygen free radical absorbing vegetables (Cao *et al*.,1996 and Sultana *et al*., 2013).

2. Total flavonoid contents in eggplant flour

The total flavonoid content of the peel of eggplant flour was higher than that found in the pulp being 1399 and 588 mg CE/100g dw, respectively. The whole eggplant flour contained 988 mg CE/100g dw (Table 4). These results are agreed with Nayanathara *et al*. (2016) who found that the highest flavonoid content was obtained in Indian black eggplant (1020.01 CE/100g dw) and the lowest was obtained in white eggplant (222.62 CE/100g dw). Moreover Jung *et al*. (2011) published that Korean eggplant peel contained highest amount of total flavonoids than pulp.

Previous studies found that purple-coloured eggplant had higher total phenolics and total flavonoid content than the white a green coloured eggplant, pale green eggplant and long green eggplant (Akanitapichat *et al*., 2010). The identification and quantification of the different flavonoids in Egyptian eggplant peel are shown in Table (5)> The highest levels of flanonoids compounds in the peel were Quercetin-3-diglucoside (30.10%), Myricetin-3-galactosid (28.20%) and Quercetin-3-rhamnoside (22.10%). These results obtained in the present study suggest that eggplant peel has a more complex flavonol profile. Garcia-Salas *et al*., (2014) reported four flavonols glycosides in whole eggplant, including quercetin-3-gentiobioside, kaempferol-3-rutinoside and two kaempferol dihexoside.kaempferol-3-rutinoside was not detected in the present study. The quercetin-3- diglucoside, kaempferol-3,7-diglucoside and another kaempferol-diglucoside reported herein are comparable to the quercetin-3-gentiobioside and two kaempferol dihexoside in the study of Garcia-Salas *et al*. (2014). Moreover, other flavonols were identified including myricetin-3-

neohesperidoside, myricetin-3-galactoside, and quercetin-3-rhamnoside, which were not reported previously in eggplant. Recently, Singh *et al*., (2017) determined and identified flavonoids in eggplant skin using HPLC and LC-MS chromatograms. They found that skin was rich in flavonoids and different flavonols were identified from eggplant skin.

3. Total anthocyanin contents in eggplant flour

The results are in the present study showed that total anthocyanin content was higher amount in eggplant peel (172 mg CGEs /100 g dw) than in eggplant pulp (8 mg CGEs per 100 g dw) while the whole eggplant flour contained 38 mg CGEs /100 g (Table 4). These results are agreed with the results of Basuny *et al*. (2012) who found that the content of anthocyanins from Egyptian black eggplant peels was 158.00mg/100g dw. On the other hand, Nino Medina *et al*., (2014) found that among the purple eggplant types, the highest amount of anthocyanins was observed in Philippine eggplant skin with 161 mgC3GE /100g, while the lowest result was found in Hindu with 83 mg C3GE/ 100g. Jung *et al*. (2011) found that the peel extract showed the highest anthocyanins content (138.05 mg %) followed by calyx (135.94 mg %), stem (110.38 mg %), leaf (97.29 mg %), and pulp (2.29 mg %) extract.

The results of Nayanathara *et al*. (2016) showed that black eggplant contained 58 mg CGEs per 100 g dw.The major four eggplant skin anthocyanins characterized by LC-MS were delphinidin 3-rutinoside-5-galactoside (4.2%), delphinidin 3-rutinoside-5-glucoside (8.1%), delphinidin-3-glucoside (3.7%) and delphinidin-3-rutinoside (84%) (Fig 2). In consistent with Wu and Prior. (2005) on whole eggplant and Ichiyanagi *et al*. (2005) on eggplant peel. delphinidin-3-rutinoside was found as the predominant anthocyanin in Egyptian eggplant skin. Although nasunin (Delphinidin-3-(p-coumaroyl rutinoside)-5-glucoside) has been reported in eggplant by prior studies (Ichiyanagi *et al*., 2005).

4. Ascorbic acid in eggplant flour

Ascorbic acid content was in higher amount in eggplant peel (17 mg /100 g) than in eggplant pulp (11 mg/100 g) while whole eggplant flour contained 15mg/100g (Table 4).Kadivec *et al*., (2015) found that ascorbic acid in flesh and peel of eggplant ranged from 12.45 to 111.01 mg/ kg. The highest ascorbic acid content, both in flesh and peel, was observed in cultivar BSS 332 (92.75 and 111.01 mg/ kg, respectively). In eggplant peel of these cultivars, ascorbic acid content ranged from 68.26 to 111.01 mg /kg, while in eggplant flesh these values ranged from 55.15 to 92.75 mg/ kg. Ji *et al*. (2011) observed higher amount of ascorbic acid in eggplant peel (5.88 mg/100 g) than in eggplant pulp (3.93 mg/100 g). Different studies showed variation levels in ascorbic acid. Ascorbic acid content ranged from 13 to 21 mg kg dw (Prohens *et al*., 2007) and from 2.91 to 6.54 mg/100 g (San Jose *et al*., 2013).On the other hand, Nino Medina *et al*. (2014) found that the ascorbic acid content in eggplant types showed values ranging between 7.4 and 22 mg $100g^{-1}$ with Thai and Hindu with lower and highest content respectively. To put consumption in perspective, Young (1999) suggested a recommended daily intake (RDI) of vitamin C in the range from 60 to 100 mg. Egyptian eggplant flour consumptions of 100 g /day as shown in the present study, will account for 7 to 22% of the RDI.

5. β-carotene in eggplant flour

β-carotene content in eggplant peel was (28 mg / 100 g) and 12 mg/100g in eggplant pulp. On the other hand, whole eggplant flour contained 19 mg /100 g (Table 4). Mbondo *et al*. (2018) found that the β -carotene content for the fresh eggplant had an average value of 20.55 mg/100 g dw. Arkoub-Djermoune *et al*. (2016) found that the carotenoid contents of different samples ranged between 42.96 and 86.60 mg bCE/100 g dw. The content of fresh eggplant was about 86.6064.26 mg bCE/100 g dw They concluded that β-carotene is subjected to isomerization and oxidation, followed by cleavage because of its unsaturated structure, particularly under the influence of heat and light during processing or storage.

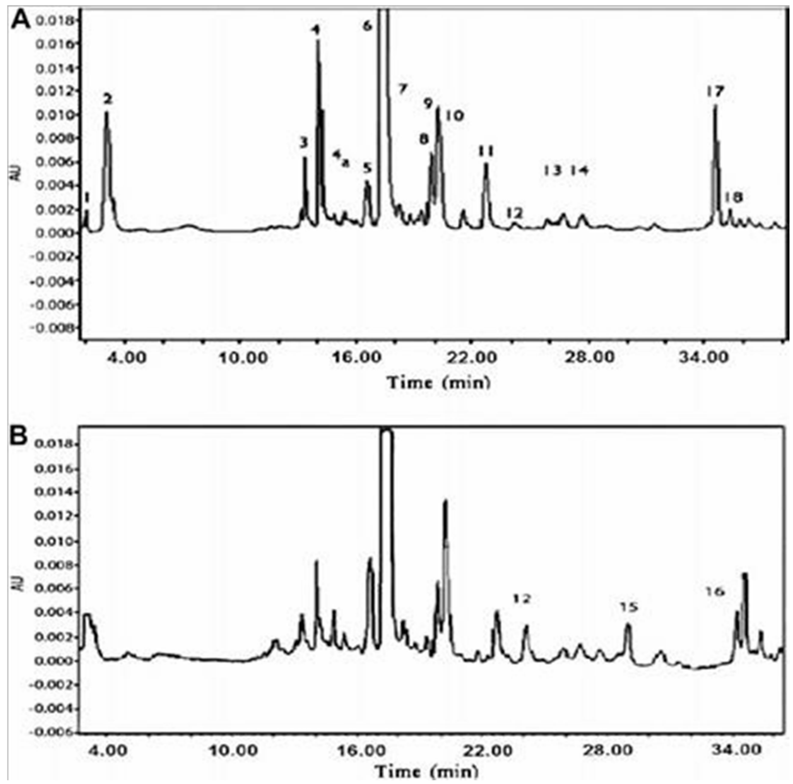
Table (4). Bioactive compounds in Egyptian eggplant flour

	Eggplant flour		
Bioactive Component	**Whole fruit**	**Pulp**	**Peel**
Total phenols (mg GAE/100g dw**)**	1815 ± 24.56[a]	926 ± 15.54[b]	3838 ± 42.88[c]
Total flavonoids (mg CE/100 g dw)	988 ± 14.98[d]	588 ± 11.32[e]	1399 ± 20.36[f]
Anthocyanins (mg CGEs per 100 g)	38 ± 2.11[g]	8 ± 0.66[h]	172 ± 7.82[i]
Ascorbic acid (mg/100 g dw)	15 ± 0.8[j]	11 ± 0.4[k]	17 ± 0.9[l]
β-Carotene (mg/100 g dw)	19 ± 0.7[m]	12 ± 0.4[n]	28 ± 0.9[o]

All values are expressed as means± SD on dry weight basis of triplicates, n=3
Means in row sharing the same superscript letter are not significantly different (p≤0.05).

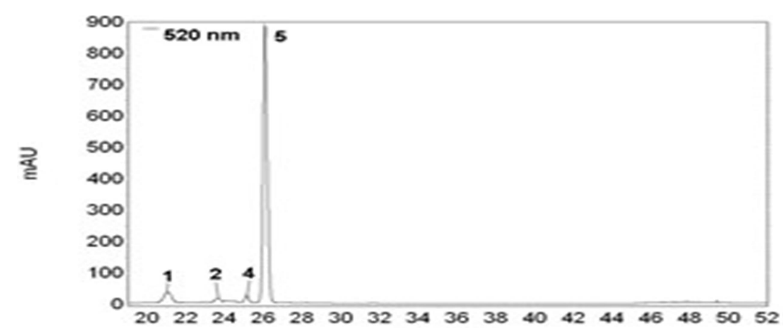
Table (5). Retention times, structure and % of total phenolic compounds extracted from eggplant peel

Peak no.	RT (min)	Structure	% total compounds
1	2.029	N-Caffeoy lputrescine derivatives	0.30
2	3.108	N-Caffeoylputrescine	2.30
3	13.319	3-Caffeoylquinic acid	0.35
4	14.077	Dihydroxycinnamoyl amide	0.25
5	16.577	N,N’-Dicaffeoyl spermidine	0.20
6	17.250	5-Caffeoylquinic acid	88.90
7	18.235	Caffeic acid conjugate	0.30
8	19.829	4-Caffeoylquinic acid	0.55
9	20.224	5-cis-caffeoylquinic acid	0.50
10	21.503	Unknown	0.20
11	22.686	3-Acetyl-5-caffeoylquinic acid	2.40
12	24.107	Myricetin-3-ᵒ-galactoside	0.40
13	25.110	Unknown	
14	27.693	Unknown	0.35
15	29.985	Quercetin-3-ᵒ-glucoside	0.25
16	34.206	Quercetin-3-rhamnoside	0.35
17	34.603	3-5-Dicaffeoylquinic acid	2.10
18	35.338	4-5-Dicaffeoylquinic acid	0.30



Fig(1). (A) HPLC profile of phenolic compounds extracted from eggplant peel at 325 nm. (B) HPLC profile of phenolic compounds extracted from eggplant peel at 366 nm

(Phenolic compounds were identified based on the ultraviolet and mass spectral data as 1. N-caffeoylputrescine derivatives, 2. N-caffeoylputrescine, 3. 3- caffeoylquinic acid, 4. dihydroxycinnamoyl amide, 4a. dihydroxycinnamoyl amide, 5. N,N'-dicaffeoylspermidine, 6. 5-caffeoylquinic acid, 7. caffeic acid conjugate, 8. 4-caffeoylquinic acid, 9. 5-ciscaffeoylquinic acid, 10. caffeic acid conjugate, 11. 3-acetyl-5-caffeoylquinic acid, 12. myricetin-3-b-galactoside, 13. 3- acetyl-4-caffeoylquinic acid, 14. caffeic acid conjugate, 15. quercetin-3-b-glucoside, 16. quercetin-3-rhamnopyranoside, 17. 3-5-dicaffeoylquinic acid, 18. 4- 5-dicaffeoylquinic acid)



Fig(2). HPLC profile of anthocyanin compounds extracted from eggplant peel and monitored at 520 nm.

(1.delphinidin. 3-rutinoside-5-galactoside, 2.delphinidin 3-rutinoside-5-glucoside, 4. delphinidin-3-glucoside and 6. delphinidin-3-rutinoside)

Table (6). Retention times, structure and relative % of total flavonoids extracted from eggplant peel.

Peak no	RT (min)	Structure	Relative % total compounds
1	14.14	Quercetin-3-diglucoside	30.10
2	14.93	Myricetin-3-neohesperidoside	3.10
3	15.31	Myricetin-3-galactoside	28.20
4	16.007	Kaempferol-3,7-diglucoside	5.20
5	16.59	Kaempferol-diglucoside	2.50
6	18.347	Quercetin-3-rutinoside	2.20
7	18.59	Quercetin-3-galactoside	1.40
8	19.26	Quercetin-3-glucoside	1.50
9	22.01	Kaempferol-3-galactoside	2.30
10	23.78	Kaempferol-3-glucoside	1.40
11	25.76	Quercetin-3-rhamnoside	22.10

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الملخص العربي

تقدير التركيب الكيماوي والمركبات النشطة حيوياً في دقيق كل من القشور واللب والباذنجان الكلى المصري

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الباذنجان (*Solanum melongena* L.) هو واحد من أشهر المحاصيل الشائعة في جميع أنحاء العالم. تم تحضير دقيق الباذنجان بواسطة التجفيد حيث أنه مكون غذائي مرغوب فيه للغاية. ومع ذلك هناك عدد قليل من المعلومات عن التركيب الكيميائي للأجزاء (اللب والقشر) للباذنجان المصري (الدقيق).

لذلك كان الهدف من هذه الدراسة هو تقدير التركيب الكيميائي والمعادن والأحماض الأمينية والمركبات النشطة حيوياً في دقيق اللب والقشور والباذنجان الكلى المصري.

أشارت نتائج هذا البحث إلى أن قشور الباذنجان احتوت على أعلى كمية من الألياف الغذائية الكلية والألياف الغذائية غير القابلة للذوبان والرماد بالمقارنة مع اللب والباذنجان الكامل .

الباذنجان غنى بالمعادن المختلفة حيث أحتوى قشر الباذنجان على كمية عالية من عناصر البوتاسيوم والماغنيسيوم والحديد والزنك مقارنة مع اللب والباذنجان الكلى. ولقد تم التعرف على ثمانية عشر من الأحماض الأمينية الضرورية وغير الضرورية في أجزاء الباذنجان بنسب مختلفة.

أوضحت النتائج أن قشور الباذنجان احتوت على أعلى المعدلات من المركبات الفينولية الكلية والفلافونويدات والأنثوسيانين مقارنة باللب والباذنجان الكامل. وباستخدام HPLC تم تحديد ثمانية عشر من المركبات الفينولية في القشور وكان الرئيسي منها هو 5-Caffeoylquinic acid (chlorogenic acid) بنسبة ٨٨.٩٪ من إجمالي المركبات الفينولية. وباستخدام HPLC-MS تم تحديد العديد من مركبات الفلافونويدات وكان الأكثر تركيزا في القشور هي:

Quercetin-3-diglucoside, Myricetin-3-galactosid and Quercetin-3-rhamnoside

وتم تحديد أربعة مركبات من الأنثوسيانين وهى: ,delphinidin 3-rutinoside-5-galactoside (4.2%), delphinidin 3-rutinoside-5-glucoside (8.1%), delphinidin-3-glucoside (3.7%) and delphinidin-3-rutinoside (84%).

علاوة على ذلك كان محتوى حامض الاسكوربيك وبيتا كاروتين أكبر في قشور الباذنجان عنها في اللب.

يستخلص من هذه النتائج أن دقيق الباذنجان وخاصة القشور تعتبر مصدراً جيداً للألياف الغذائية والمعادن والمركبات النشطة حيوياً ويمكن استخدامها كمكملات غذائية في الوجبات الغذائية المنخفضة في مثل هذه المركبات.