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Healthy sorbet with eggplant peel and beet stalk-leaves extracts as natural colorants

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Abstract

Food's colour is a crucial component and has a big impact on how people will react to it. Natural dyes that have antioxidant and antibacterial effects in addition to their use as natural colourants should be used instead of toxic industrial dyes by people. The phytochemicals, antioxidant activity, and antibacterial activity of beet stalk-leaves and eggplant peel extracts were identified in these studies. In comparison to beet stalk- leaf extract, eggplant extract had higher levels of total phenols, anthocyanins, and flavonoids (50.21 mg GAE/g, 2.3 mg MvE/g, and 7.17 mg CE/g). In contrast to eggplant peel extract, beet stalk-leaf extract had higher concentrations of chlorophyll A, chlorophyll B, and carotene (1.42, 0.6, and 68.7 mg/g, respectively). The antioxidant activity was 18.31 and 14.39 mg TE/g.in eggplant peel and beet stalk-leaves extracts. The extracts were more effective on positive- gram bacteria and saccharomyces cerevisiaethan negative- gram bacteria. The addition of extracts improve the quality of sorbet where the highest titratable acidity: total soluble solids (TSS: TAA) ratio was found in 2% beetroot stalk-leaf extract sorbet (23.47) compared to (sorbet with tartrazine dye). The parameter L* (lightness) and a*(redness) of sorbet decreased while the b* (yellowness) value Increased by increasing the concentration of extract. Using natural pigments improve the taste from 8.17 in sorbet with tartrazine dye to 8.67 in 2% eggplant peel extract sorbet. This study aims to overcome the problems of artificial colors and their health damage using eggplant peel and beetroot stalk-leaf extracts and application in sorbet.

Keywords: Eggplant peel, beet stalk–leaves, natural pigments, Tartrazine, sorbet

1. Introduction

Food colour has an impact on how well-liked food is. Previously, chemicals or synthetic materials were used to create food colours. However, natural pigments are gradually replacing synthetic ones in the supply of materials for food colouring. This was done to make natural pigments more appealing to consumers while also utilising their useful qualities, such as bioactivity, anticancer potential, and vitamin. Polyphenols, anthocyanins, chlorophylls a and b, carotenoids, and other healthy compounds are found in natural colours. Strong antioxidants, diabetic inhibitors, vasoprotectors, anti-inflammatories, cancer fighters, chemoprotectors, and anti-neoplastics are all functions of these compounds. Carotenes are a precursor to vitamin A. By using natural pigments, one can reduce the risk of contracting numerous diseases and avoid the drawbacks of artificial colouring. [1] One of the most common uses of natural or artificial colourants is to change or preserve the apparent look of foods. Food colouring plays a vital function in food production, hiding undesirable characteristics or enhancing natural food

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attributes [2]. Natural food-colorants are gradually becoming chosen due to changing consumer lifestyles and increased concerns about potential detrimental health effects and environmental damage caused by synthetic colourants [3]. Due to a known health risk associated with synthetic colourants, natural colourants have arisen as a viable alternative. Furthermore, natural-food colourants are a sustainable option that provides health benefits as well as unique technological and sensory properties to the food systems that use them. Several natural colourant sources have been investigated in order to provide the requisite wide colour range demanded by consumers [4].

Anthocyanins are pigments, dyes, or colouring agents produced from plants that are utilised as natural colour additives in the colour of certain items such as soft drinks, yoghurt, jam, or to revive certain types of cuisine. [5]. Anthocyanin is a common water-soluble flavonoid with pH-dependent colours ranging from red to blue and bioactive properties including antioxidant, anti-inflammatory, hypoglycemic, and protective effects [6]. Vegetable production and processing generates a vast number of by-products, with losses of up to 75% of collected material in some situations. The leaves of plants farmed for their roots (carrots, beets, and turnips) are typically discarded as garbage after harvest [7]. Red beetroot (*Beta vulgaris* L.) is an antioxidant and anti-inflammatory food that is traditionally consumed all over the world. It contains vitamins, minerals, polyphenols, betacyanins, and betaxanthins. [8 and 9]. Beetroot and several of its derivatives (leaves and steams) exhibit anticarcinogenic and hepatoprotective effects on oxidative stress and inflammation. [10]. Phenolic acids (gallic, vanillic, chlorogenic, ferulic, caffeic, syringic) and flavonoids are found in beet stalks (myricetin, quercetin, rutin, and kampferol). Beet stalks can assist to improve endogenous antioxidant defences and protect cellular components from oxidation when consumed as part of a healthy diet. [11]. Betacyanin is a natural colourant derived primarily from beetroot that is a good substitute for synthetic colourants because it has no harmful effects and a well-established daily intake rate [12]. Eggplant fruits (*Solanum melongena* L.) are widely consumed around the world due to their generous composition of nutraceuticals [13]. Egypt produced roughly 1.18 million metric tonnes of eggplants in 2019. Due to the high amount of phenol and anthocyanins, this plant has gained a lot of attention as a functional food in recent years, and it has been named one of the top ten vegetables with antioxidant capacity [14]. Various phenolic compounds are present in eggplants, just as they are in other fruits and vegetables. The most significant of these compounds, anthocyanins, are present in the peels as an example. Due to anthocyanins' capacity to attach to proteins and sugars as well as the fact that each plant's matrix differs in composition, it is challenging to extract anthocyanins from the outer layers of eggplants. The delphinidin glycosides are responsible for the purple colour of eggplant skin. [15 and 16]. Eggplant peels can be used as a rich source of plant compounds, as well as a natural pigment substitute for industrial pigments in the colouring of industrial beverages [17]. Sorbet, also referred to as "Italian ice" or "water ice," is a frozen treat made from flavouring and sugar-sweetened water. The word "sorbet" in English is derived from the şerbet-derived Old Italian sorbet. Sorbets frequently include no dairy ingredients. Sorbets are tasty frozen treats that vegetarians and vegans prefer over ice cream [18]. If the right ingredients are utilised, sorbets may even bear the label "bio" [19]. The food processing sector has long expected a zero-waste production cycle as well as waste valorization through the recovery of high-added-value chemicals. The purpose of this study is to extract natural pigments from beetroot stalk-leaf and eggplant peels in order to investigate the phytochemical substances present and their antioxidant and antibacterial properties. In addition to examining how these components affect the sorbet's physical, aesthetic, and sensory qualities.

2. Materials and Methods

2.1. Raw Materials and chemicals

Black eggplant (*Solanum melongena* L.) and beet (*Beta vulgaris* L.) were purchased from specialized farms (Tanta, Egypt). Artificial color, tartrazine E102 obtained from Kamena Company Giza. All solvents and reagents from various suppliers were of the highest purity needed for each application and used without further purification and purchased from Sigma Company for Chemicals and Drugs.

2.1.1. Preparation of materials

The eggplant cleaned well and peeled with a sharp knife to get the peels without the core. The stalks and leaves removed from beets and cleaned well. The eggplant peels and beet stalks and leaves were cut into very small pieces and put in an air oven at 40°C until completely dried, then the samples were grinded well to be suitable for the extraction process [17].

2.1.2. Extraction of natural pigments from eggplant peels and beet stalks and leaves

The pigments extracted from eggplant peels and beet stalks and leaves with methanol (70% in water) acidulated with citric acid 1% with concentrate 1:10 (w:v). The mixtures were stirred for 1h at room temperature then left in the refrigerator overnight. The mixtures were filtered using a Wattman filter paper No.42. The dyes extract concentrated by rotary evaporation at 100 rpm/40ºC for 5min. All extracts were stored in dark bottles in a freezer at -18 ºC until uses [20].

2.2. Determination of phytochemical in eggplant peels and beet stalks and leaves extracts

2.2.1. Determination of total phenolic content

The total phenolic content was determined according to the Folin-Ciocalteu procedure [21]. In a nutshell, the extract (100 µL) was put into a test tube, the volume was corrected to 3.5 mL with distilled water, and the addition of 250 µL caused the extract to oxidase of Folin-Ciocalteau reagent. After 5 min, the mixture was neutralized with 1.25 mL of 20% aqueous sodium carbonate (Na_2CO_3) solution. The absorbance was measured at 725 nm against a solvent blank after 40 min. A calibration curve made with gallic acid was used to calculate the total phenol concentration, which was then represented as milligrams of gallic acid equivalent (mg GAE) per g of sample. If the measured absorbance value was greater than the linear range of the standard curve, additional dilution was carried out.

2.2.2. Determination of total flavonoid content

According to [21], a colorimetric test utilizing aluminum chloride (AlCl3) was used to determine the total flavonoid concentration. In a nutshell, 100 µL of extract was combined with 300 µL of 5% sodium nitrite (NaNO2). 300 µL of a 10% AlCl3 solution was added after 6 minutes, and the volume was then changed with distilled water to 2.5 mL. After 7 minutes, 1.5 mL of 1M NaOH was added, and the mixture was centrifuged at 5000 g for 10 minutes. The absorbance of the supernatant was determined at 510 nm in comparison to a solvent blank. By using a calibration curve created using a catechin machine, the total flavonoid content was calculated and expressed as milligrams of catechin equivalent (mg CE) per gram of sample. If the measured absorbance value was greater than the linear range of the standard curve, additional dilution was carried out.

2.2.3. Determination of total pigments

Extraction of carotenoids was carried out in stoppered tubes according to [22]. Samples were prepared with a laboratory homogenizer using about 1 g material. Samples were extracted using methanol. The extraction ratio was 1:50. Centrifugation is used to separate the homogeneous mixture for 10 minutes at 3000 rpm. The analytical determination was performed with spectrophotometer at the following wavelengths: 666, 653, 470 nm for chlorophyll a, b and carotene. Equations used for calculation are presented below.

Chlorophyll a = 15.65 A666 – 7.340 A653

Chlorophyll b = 27.05 A653 – 11.21 A666

Carotene = 1000 A470 – 2.860 Chl a – 129.2 Chl b/245

2.2.4. Determination of anthocyanin

According to [23], the total anthocyanin content was calculated. In this procedure, 20 mL of 2% HCl (pH 0.6) solution and an equal volume of ethanol acidified with 0.1% HCl and 1 mL of each extract were added. 0.8 mL of water and 2 mL of the prior solution were combined in one tube (t1). 2 mL of the prior solution and 0.4 mL of HNaSO3 solution (15% w/v) were combined in a different tube (t2). The absorbance was determined at 520 nm following 20 min in complete darkness and at room temperature. The following equation was used to determine the total anthocyanin:

Total anthocyanin (mg Mv3G/g) = 875 × ($abst_1$ - $abst_2$)

Where: Mv_3G – malvidin-3-glucoside equivalents.

The results expressed as malvidin equivalents, according with the mass of sample and volume of extract.

2.3. Determination of radical DPPH scavenging activity in eggplant peels and beet stalks and leaves extracts

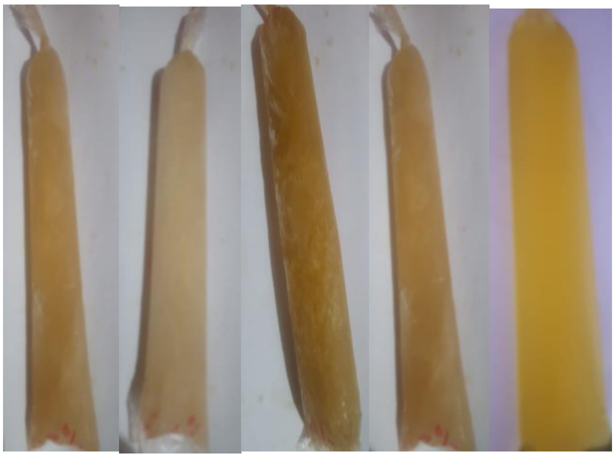
According to Hwang et al. [24], the stable DPPH method was used to assess the ability of extracts to scavenge free radicals. The reaction's total volume was 3.0 mL, and the final concentration for DPPH was 200 M. The absorbance was measured at 517 nm against a blank of pure methanol after 60 min of incubation in the dark. Trolox was used to prepare the standard curve. Results were given in milligrammes of trolox equivalents (TE) per gramme of material. If the detected DPPH value was over the standard's linear range, more dilution was required.

2.4. Determination of zone of inhibition method in eggplant peels and beet stalks and leaves extracts

The extracts were screened for their antibacterial and antifungal activities against the *Bacillus cereus, Listeria monocytogenes, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Salmonella typhimurium* and the fungi *Penicillium digitatum* ATCC 10030, *Candida albicans* ATCC14053, *Saccharomyces cerevisiae* ATCC9763. One ml of a fresh bacterial or fungal culture was pipetted onto the center of a sterile Petri dish, as shown by [25].Molten cooled Muller Hinton agar (MHA) for bacteria strains or Potato dextrose agar (PDA) for fungi was then poured into the Petri dish containing the inoculum and mixed well. After solidifying, wells were drilled into agar plates containing inoculums using a sterile cork borer (6 mm in diameter). Then, 100 µl (20% w/v) of each extract was applied to the appropriate wells. We chose the extract concentration (20% w/v) based on our pre-experiments and prior research. To allow the extracts to properly diffuse into the agar, the plates were placed in the refrigerated for 30 minutes. The plates were then incubated for 18 hours at 37°C.By measuring the zone of inhibition, which included the wells' diameter, following the incubation period, antimicrobial activity was discovered. As a negative control, 10% DMSO concentration was used.

2.5. Preparation of sorbet with eggplant peels and beet stalks and leaves extracts as natural colorants

Sorbet was prepared according to method of [17] with mixed 15% sugars, 84.20% water and 0.20% citric acid very well and heated at 90ºC for 15 min., cooling until reaches 40ºC and then added the extract



(e) (d) (c) (b) (a)

a= sorbet with tartrazine dye

b=Sorbet with 1% beet stalk-leafextract

c=Sorbet with 2% beet stalk-leafextract

d=Sorbet with 1% eggplant peel extract

e=Sorbet with 2% eggplant peel extract

deys at concentrate 1 and 2%. The synthetic colors added at concentrate 0.1%, then all mixes put in polyethylene bags and placed in deep freezer at -18ºC.

2.6. Determination of total soluble solids, pH and titratable acidity in sorbet prepared with eggplant peels and beet stalks and leaves extracts as natural colorants

The total soluble solids (TSS) values of sorbet were recorded at 20°C using an Abbe refractometer (ATAGO, Japan). The pH values of samples were acquired at room temperature and a constant agitation with pH meter (model Consort P107). The pH meter was calibrated at pH 4.0, 7.0 and 10.0 prior to use. Titratable acidity (TA) of samples was estimated by titrating 10 ml of sorbet with 0.1 N sodium hydroxide (NaOH) solution using 0.3 mL phenolphthalein as an indicator, light pink color persisting for 30 seconds is taken as an end point, the obtained TA values were expressed as %, citric acid [26]. The ratio of TSS/TTA was calculated for each sample by dividing the total soluble solids (TSS) by the total titratable acidity (TTA) of the same sample.

2.7. Determination of Color

The color of sorbet samples was measured using Hunter Lab color system (Hunter, Lab Scan XE - Reston VA, USA). The instrument was calibrated using a white tile (L*= 92.46; a*= - 0.86; b*= -0.16). Color values were expressed as L* (lightness or brightness/ darkness), a* (redness/greenness) and b* (yellowness / blueness) according to [27].

2.8. Sensory evaluation of sorbet:

Sensory evaluation was carried out by ten panelists from Food Science and technology Department, Faculty of Home Economic, Al-Azher Univ., Tanta. The panelists were asked to evaluate color, taste, odor and overall acceptability for prepared sorbet according to the method described by [17].

2.9. Statistical analyses

The sensory evaluation and chemical composition data were recorded as means and examined using (SPSS) Windows (Ver.10.1). To identify differences between various treatments, Duncan comparisons and one-way analysis of variance (ANOVA) were tested.

3. Results and Discussions

3.1. Phytochemicals and antioxidant activity

The Folin-Ciocalteu method is widely used to evaluate the total content of phenols [28]. Totalphenol content in beet stalk-leaf in this study (17.02 mg GAE/ g) was 33.89% less than that eggplant peel extract (50.21 mg GAE/g). Nisha *et al* [29] reported that, the use of methanol gave a value of 49 mg / 100 g, and when using ethanol 70% got 55 mg / 100g in eggplant peels [30]. Total anthocyanin content observed in eggplant peel extract (2.3 mg MvE/g) was more than four times greater than beet stalk-leaf (0.56 mg MvE/g). The amount of anthocyanins found in eggplant peels was 2.3 mg MvE/g, falling within the range determined by [31], which ranged between (0 -113.81) mg/100 g when these pigments were estimated in many of the genotypes examined that had diverse colours: While the dark purple colour was caused by the presence of pigment Delphidin that was transformed by the acylation process, in addition to what was added as dark colour by chlorophyll, Kumari et al. [31] attributed the difference in the percentage of pigments to the variety. [32]. When compared to the findings of [33], which represented (0.014-0,039) % of the fresh peels of the eggplant varieties they tested, flavonoids in eggplant peels reached 7.17 mg CE/g and were high.

These numbers are also high according to the categorization [34], which divided the concentration of flavonoids in foods into three categories: low (0.1 to 39.9), medium (40.0 to 99.9), and high (greater than 100) ppm. when the DPPH test for radical scavenger activity of the extracts was finished. greatest radical scavenging activity at 18.31%. This suggests that the phenols in the eggplant peel extract may have been given chemical characteristics that improved their capacity to scavenge free radicals. According to Sarkar et al. [5], the anthocyanin is a combination of cis-trans isomers of delphinidin due to its acylation. It has very strong antioxidant properties. It forms a compound with Fe^{3+} and prevents the generation of hydroxyl free radicals, which are needed for iron chelation. These results showed that, level of chlorophyll-a in beet stalk-leaf was 1.42 mg/g and chlorophyll-b was 0.6 mg/g. The content of chlorophyll-a was dominated over chlorophyll-b being by 2.37 times higher. Chlorophyll-a is the primary photoreceptor, and plants typically contain 2-4 times more of it than chlorophyll-b [35]. **Table (1)** also shows the higher value of carotenes in beet stalk-leaf than in eggplant peels (68.7 and 11.7) mg/100g respectively, while Tharasena and Lawan [36] indicated that eggplant flesh is poor in these compounds as it contains 3.05 mg/100g.

Table 1. Phytochemical and antioxidant activity of eggplant peels (EP) and beetstalk-leaf extracts (BSL)

sample	Total Phenols (mg GAE/g)	Total anthocyanins (mg MvE/g)	Total Flavonoids (mg CE/g)	DPPH (mg TE/g)	Carotenoids (mg/g)		
					Chlorophyll A	Chlorophyll B	Carotene
EP	50.21±0.23	2.3±0.05	7.17±0.13	18.31±0.94	0.34±0.01	0.2±0.00	11.6±0.41
BSL	17.02±0.52	0.56±0.01	5.46±0.42	14.39±0.45	1.42±0.02	0.6±0.01	68.7±0.81

EP= eggplant peels extract
BSL= beetstalk-leaf extract

3.2. Antimicrobial activities

Different levels of antibacterial activity were present in both extracts against the tested species. The result is presented in **Table** 2. The extract of eggplant peels showed inhibition of growth of *Bacillus cereus, Staphylococcus aureus, Listeria monocytogenes*, *Escherichia coli,* and *Salmonella typhimurium*, but no zones of inhibition were shown against *Pseudomonas aeruginosa*. The information suggests that the extract displayed the activity against the food pathogens under investigation. Compared to Gram-negative bacteria, Gram-positive bacteria showed a higher vulnerability. The mean diameter of zone of inhibition against *Staphylococcus aureus* and *Bacillus cereus* were 19±1.08 mm and 18±0.98 mm respectively.

It's primarily due to the presence of a large class of siloxanes that have been detected significantly in the extracts. Antibacterial properties of siloxanes have been earlier reported by [34]**,** when they had discovered these in conventional seed oils. Also in the extract of beetstalk-leaf, the mean diameter of zone of inhibition against *Bacillus cereus* was 15±1.00 mm and that of *Listeria monocytogenes* was 14±1.12 mm.The extract of beetstalk-leaf has the higher antimicrobial activity against *Listeria monocytogenes* than the standard commercial chloramphenicol. The beet stalk-leaf extracts showed zone of inhibition only against *Salmonella typhimurium* with mean diameter of 13±1.19 mm.

Table 2. Antimicrobial activities (mm) of eggplant peels (EP) and beetstalk-leaf extracts (BSL)

No	Test Strains	Zone of inhibition (mm) EP	BSL	positive control
	Bacteria			***chloramphenicol***
1	***Bacillus cereus***	**18.90±0.98**	**15.00±1.00**	**26.00±1.00**
2	***Staphylococcus aureus***	**19.54±1.08**	**14.22±1.53**	**16.00±0.00**
3	***Listeria monocytogenes***	**17.12± 0.64**	**14.60±1.12**	**12.00±0.00**
4	***Escherichia coli***	**16.30±1.15**	**12.17±0.57**	**23.00±0.00**
5	***Pseudomonas aeruginosa***	**ND**	**ND**	**11.18±0.52**
6	***Salmonella typhimurium***	**13.98±1.52**	**13.67±1.19**	**23.00±0.00**
	Fungi and yeast			**Nystatin**
7	***Penicilliumdigitatum* ATCC 10030**	**16.54±1.15**	**13.00±2.00**	17.32±0.15
8	***Candida albicans* ATCC14053**	**ND**	**ND**	**22.76±1.81**
9	***Saccharomyces cerevisiae* ATCC9763**	**18.80±0.57**	**16.17±1.52**	**17.00±0.00**

Data is presented as mean ± standard deviation. * denotes significance at p ≤ 0.05. ND = Not detected. EP= eggplant peel extract, BSL= beetroot stalk and leaves

The therapeutic basis for the antibacterial activities seen in these extracts is provided by the presence of several phytochemical elements in the leaf extract. The result further suggests that, *Bacillus cereus* was more susceptible to the extract of eggplant peels when compared with *Escherichia coli*. This result is consistent with [38] who described the *in vitro* antioxidant and antimicrobial activities of ethanol, acetone, and water extracts of beet root pomace. *Bacillus cereus* and *Staphylococcus aureus* showed greater susceptibility to antibacterial agents in testing than did *Escherichia coli* and *Pseudomonas aeruginosa*. The extract of eggplant peels showed a powerful antifungal activity against *Penicillium digitatum*. In this study results indicated that, extracts exhibited strong activity on yeast *Saccharomyces cerevisiae*, and the extract of eggplant peel has almost the higher activity than the standard commercial fungicide nystatin. but no zones of inhibition were shown against pathogenic yeast *Candida albicans.* [39] also has reported the antimicrobial activity of beetroot dye against the *E. coli* and other specific microorganisms like *Salmonella spp*. *Staphylococcus aureus*, *Pseudomonas* spp., yeast and moulds.

3.3. Physicochemical properties of the sorbet

Table 3 lists the physicochemical variables, such as pH, total titratable acidity (TTA), total soluble solids (TSS), and the TSS:TAA ratio**.** As demonstrated from the results that, the tartrazine dye sorbet (TDS) gave the highest pH value (7.76) and the lowest values of TTA and TSS (0.17 and 3.18) compared to sorbet containing natural pigments. [37] demonstrated that the tartrazine solution has pH 8 at room temperature. There were significantly differences ($p \leq 0.05$) between sorbet containing natural pigments in total titratable acidity (TTA) and pH values that reached to 0.25 and 5,66 in 2% eggplant peel extract sorbet (EPS), While these values reached 0.19 and 6.65 in 2% beet stalk-leaf extract sorbet (BS-LS), respectively. The decreased in pH and acidity of EPS compared to (BS-LS) may be due to the pH and acidity values of eggplant peel and beet stalk–leaf extracts. [38] found that the pH and acidity of beet stalk-leaf juice were 6.66 and 0.13% as citric acid. [39] mentioned that, the pH value of eggplant peel extract was 4.15.

Table 3. Physicochemical properties of the sorbet with eggplant peel and beet stalk-leaf extract compared to control (containing tartrazine dye)

Parametar	TTA%	pH	TSS (ºBrix)	Tss/TAA
TDS	0.15 ± 0.010^{d}	7.76 ± 0.011^{a}	3.18 ± 0.028^{b}	21.20 ± 0.20^{b}
EPS 1%	0.28 ± 0.013^{a}	5.61 ± 0.060^{d}	4.50 ± 0.016^{a}	16.07 ± 0.022^{e}
EPS 2%	0.25 ± 0.025^{ab}	5.66 ± 0.026^{d}	4.53 ± 0.023^{a}	18.12 ± 0.12^{d}
BS-LS 1%	0.21 ± 0.050^{bc}	6.35 ± 0.040^{c}	4.38 ± 0.041^{a}	20.85 ± 0.050^{c}
BS-LS 2%	0.19 ± 0.011^{cd}	6.65 ± 0.050^{b}	4.46 ± 0.025^{a}	23.47 ± 0.070^{a}

Where : TDS= sorbet with tetrazine dye, EPS= sorbet with eggplant peel extract, BS-LS= sorbet with beetroot stalk–leaf extracts, TTA= titratable acidity, TSS= total soluble solids

The total soluble solid of sorbet increased significantly (p≤0.05) from 3.18 (ºBrix) in TDS to 4.53(ºBrix) in EPS 2%. Hosseini *et al* [42] found that, the TSS of eggplant peel extract was 14.32 (ºBrix) while Abdo *et al* [41] found that, the TSS of beetroot stem–leaf extract was 3.70 (ºBrix). This explains the reason for the decrease TSS in BS-LS compared to EPS. The total soluble solids: total titratable acidity (TSS: TAA) ratio is a good indicator of the juice's quality and the consumer acceptability [43]. The highest (TSS: TAA) ratio was found in BS-LS 2% (23.47).

3.4. Color properties of sorbet

The color of an object can be described by several color coordinate systems, the most popular systems are Hunter L, a, b [41]. The L*, a* and b* values were measured in Table 4. The L* values takes positive values for lightness color, whereas b* values takes positive values for yellowish colors and parameter a* takes negative values for reddish colors. The greater EP and BS-LS extracts level of addition, the lower L*, a* and higher b* values were recorded. The L* values significantly(p≤0.05) decreased from 89.44 in TDS (sorbet containing tartrazine dye) to 80.88 in EPS 2% (sorbet containing 2% eggplant peel extract) and 59.07 in BS-LS 2% (sorbet containing 2% beet stalk and leaves).

Table 4. Color characteristics of the sorbet with eggplant peel and beet stalk-leaf extracts compared to control (containing tartrazine dye)

Color	L*	a*	b*
TDS	89.44±0.44^{b}	-3.84± 0.045^{e}	14.83± 0.030^{b}
EPS 1%	91.22± 0.02^{a}	-0.44± 0.015^{a}	8.47± 0.025^{e}
EPS 2%	80.88± 0.02^{c}	-0.67± 0.02^{b}	13.64± 0.040^{d}
BS-LS 1%	65.00± 0.015^{d}	-0.98± 0.02^{c}	14.41± 0.020^{c}
BS-LS 2%	59.07±0.13^{e}	-1.18± 0.16^{d}	16.74± 0.047^{a}

Where: TDS= sorbet with tartrazine dye, EPS= sorbetwith eggplant peel extract, BS-LS= sorbet with beetroot stalk–leaf extracts, L* (lightness), a* (redness) and b* (yellowness)

The parameter a* decreased significantly (p≤0.05) by increasing the concentration of the extracts but all parameters a* were higher than the TDS (sorbet containing tartrazine dye). Finally, the parameter b* increased significantly (p≤0.05) by increasing the concentration of the extracts from 8.47 in sorbet containing 1% eggplant peel extract to 13.64 in sorbet containing 2% eggplant peel extract) and from 14.41 in sorbet containing 1% beet stalk and leaves to 16.74 in sorbet containing 2% beet stalk and leaves.

3.5. Sensory evaluation of the sorbet

This study included the production of the sorbet using pigments extracted from eggplant peels and beet stalk-leaf as natural colorants and conducted sensory evaluation for products **Table (5)**. The results showed that there were no significant differences (p<0.05) in taste values between the sorbet prepared with 1% BS-L extract and control (8.17). The highest test values appeared in sorbet prepared with eggplant peel extracts 1 and 2% (8.33 and 8.67, respectively). The results also showed no significant differences between control and sorbet with 2% BS-L compared to other sorbets. While the decreasing was noted in the values of the odor in sorbet prepared with EPS and BS-LS extracts compared to control sorbet. may be due to the type and concentration of the pigments contained in these peel and the method of extracting them in addition to the type of extraction medium.

Table 5. Sensory evaluation of the sorbet with eggplant peel and beet stalk-leaf extracts compared to control (containing tartrazine dye)

Parameters	Taste	Color	Odor	Acceptability
TDS	8.17±0.289 [ab]	9.00± 0.00 [a]	8.33± 0.58 [a]	8.33± 0.29[a]
EPS 1%	8.33± 0.58 [a]	7.33± 0.58 [c]	6.67± 0.58 [c]	7.50± 0.50 [b]
EPS 2%	8.67± 0.58 [a]	8.00± 0.00 [b]	7.00± 1.00[b]	7.50± 0.50 [b]
BS-LS 1%	8.17± 0.29[ab]	8.17± 0.29 [b]	7.00± 0.00 [b]	7.67± 0.29 [b]
BS-LS 2%	8.00± 1.00 [b]	9.00± 0.00 [a]	7.00± 0.34 [b]	8.00± 0.50 [a]

Where: TDS= sorbet with tartrazine dye, EPS= sorbet with eggplant peel extract, BS-LS= sorbet with beetroot stalk–leaf extracts

The results of the general acceptance in TDS, EPS 1%, EPS 2%, BS_LS 1% and BS-LS 2% scored values 8.33, 7.50, 7.50, 7.67 and 8.00, respectively. There were no significant differences between TDS and BS-LS in acceptability compared to other sorbets. In general, the sensory evaluation results show that the natural pigments investigated were successful in producing outcomes that were comparable to or similar to the artificial pigments used in the industrial sorbet, the results were consistent with those of [17] who also used the natural pigments (betalain) instead of the Carmine dye when producing ice cream.

The findings support the potential for employing plant residues such as beet stalk and leaf and eggplant crusts as rich sources of plant compounds and for the creation of eco-friendly colors.

CONCLUSION

According to this study, beet stalk and eggplant peel extracts had high levels of carotenoid, anthocyanin, and phenolic components as well as significant radical scavenging action against stable DPPH.as well as antimicrobial activity of these extracts. The extracts added to the sorbet with concentrate 1 and 2% as artificial colorant replacer (tartrazine). The physicochemical, color and sensory properties of sorbet were evaluated. The natural extracts improve the quality, yellowness, taste and acceptability of sorbet. Our results showed that eggplant peels and beet stalks-leaf, an inedible waste product, might be a potent source of antioxidants, and has a potential as a value-added ingredient for functional foods.

References

1- Mille, J. Plant pigments in functional foods developments. J Food Drug Res 6 (1):1-4 (2022). www.pulsus.com/scholarly-articles

2- Nwoba, E.G.; Ogbonna, C.N.; Ishika, T. and Vadiveloo, A. Microalgal pigments: A source of natural food colors. In microalgae biotechnology for food, health and high value products; Asraful, A.M.; Xu, J. and Wang, Z., Eds.; Springer: Singapore, pp.81-123, (2020).

3- Albuquerque, B.R.; Oliveira, M.B.P.; Barros, L.; Ferreira, I.C.F.R. Could fruits be a reliable source of food colorants? Pros and cons of these natural additives. *Food Science* and *Nutrition*, 1-31, (2020). [CrossRef] [PubMed].

4- Luzardo-Ocampo, I.; Ramírez-Jiménez, A.K.; Yañez, J.; Luis Mojica, L. and Luna-Vital, D.A. Technological applications of natural colorants in food systems: A review. foods, 10(634):1-34, (2021). https://doi.org/ 10.3390/foods10030634

5- Sarkar, J.; Kumar, N. and Gupta, P. Extraction evaluation and standardization of nasunin from peels of *Solanum melongena* L. purple peel fruits. International Journal of Creative Research Thoughts (IJCRT), 8(6): 2320-2882, (2020). www.ijcrt.org

6- Enaru, B.; Dret, G.; Pop, T.D. Stanil, A. and Diaconeasa, Z. Anthocyanins: Factors affecting their stability and degradation. Review. Antioxidants, 10:1-24, (2021). https://doi.org/10.3390/antiox10121967

7- Fernández, G.M.V.; Jagus, R.J. and Agüero, M.VEvaluation and characterization of nutritional, microbiological and sensory properties of beet. Acta Scientific Nutritional Health, 1(3):37-45, (2017). https//:notablesdelaciencia.conicet.gov.ar

8- Lechner, J.F., and Stoner, G.D. Red beetroot and betalains as cancer chemopreventative agents. Molecules, 24(8):1602, (2019).

9- Ceclu, L. and Nistor, ORed Beetroot: Composition and health effects - A review. Ceclu and Nistor. *Journal* of Nutritional *Medicine* and *Diet Care,* 6(1):1-s9. doi.org/10.23937/2572-3278.1510043, (2020).

10- Chhikara, N.; Kushwaha, K.; Sharma, P.; Gat, Y. and Panghal, A. Bioactive compounds of beetroot and utilization in food processing industry: A critical review. Food Chemistry, 272:192-200, . (2019).

11- Lorizola, I.M.; Furlan, C.P.B.; Mariana Portovedo, M.; Milanski, M.; Botelho, P.B.; Bezerra, R.M.N.; Sumere, B.R.; Rostagno, M.A. and Capitani, C.D. Beet stalks and leaves (*Beta vulgaris* L.) protect against high-fat diet-induced oxidative damage in the liver in mice. Nutrients, 10(872):1-16, (2018). doi:10.3390/nu10070872

12- MayuriOmae, J.; Goto P.A.; Rodrigues L.M.; Santos S.S.; Moser Paraiso, C.; Madrona G. and Bergamasco, R.D.C. Beetroot extract encapsulated in inulin: storage stability and incorporation in sorbet. Chemical Engineering Transactions, 57:1843-1848, (2017). DOI: 10.3303/CET1757308

13- Gürbüz, N.; Uluişikb, S.; Frarya, A.; Fraryc, A.; Doğanlara, S. Health benefits and bioactive compounds of eggplant. *Food Chemistry*, 268:602-610, (2018).

14- Niño-Medina, G.; Urías-Orona, V.; Muy-Rangel, M.D. and Heredia, J.B. Structure and content of phenolics in eggplant (*Solanum melongena*)-a review. South African Journal of Botany, 111:161-169, (2017).

15- Condurache, N.; Croitoru, C.; Elena Enachi, E.; Bahrim, G.; Stănciuc, N. andRâpeanu, G. Eggplant peels as a valuable source of anthocyanins: Extraction, thermal stability and biological activities. Plants, 10(577):1-16, (2021). https://doi.org/10.3390/plants10030577

16- Ferarsa, S.; Zhang, W.; Moulai-Mostefa, N.; Ding, L.; Jaffrin, M.Y.; Grimib, N. Recovery of anthocyanins and other phenolic compounds from purple eggplant peels and pulps using ultrasonic-assisted extraction. *Food* and *Bioproducts Processing*, 109:19-28, (2018).

17- Al-Abdulla, B.Y. and Oleiwi, S.D. Estimation of some phytochemicals in extract of eggplant peels and cabbage leaves and using of pigment of them in drinks industry. *Mesopotamia journal of Agriculture*, 47(2):128-138, (2019).

18- Petkova, T.; Doykina, P.; Alexieva, I.; Mihaylova, D.; Popova, A. Characterization of Fruit Sorbet Matrices with Added Value from Zizyphusjujuba and Stevia rebaudiana. Foods, 11(2748): 1-13 (2022). https:// doi.org/10.3390/foods11182748

19- Kim, S.; Meyers, S.L.; Silva, J.L.; Schilling, M.W.; Wood, L.S. Sensory and Nutritional Characteristics of Concept Frozen Desserts Made from Underutilized Sweetpotato Roots. Horttechnology, 31: 259–265 (2021). [CrossRef]

20- Gamila, A.Y.; Moussa, M.E.M. and Sheashea, E.R. Characterization of red pigments extracted from red beet (*Beta valgaris*, L.) and its potential uses as antioxidant and natural food colorants. *Egyptian Journal of Agricultural Research*, 91(3), (2013).

21- Zilic, S.; Serpen, A.; Akillioglu, G.; Jankovic, M. and Gokmen, V. Distributions of phenolic compounds, yellow pigments and oxidative enzymes in wheat grains and their relation to antioxidant capacity of bran and debranned flour. Journal of Cereal Science, 56:652-658, (2012).

22- Costache, M.A.; Campeanu, G. and Neata, G. Studies concerning the extraction of chlorophyll and total carotenoids from vegetables. Romanian Biotechnological Letters, 17:7702-7708, (2012).

23- Boulton, R. The copigmentation of anthocyanins and its role in the color of red wine: a critical review. American Journal of Enology and Viticulture, 52:67–87, (2001).

24- Hwang, E.S. and Do Thi, N. Effects of extraction and processing methods on antioxidant compound contents and radical scavenging activities of laver (Porphyratenera). Preventive Nutrition and Food Science, 19:40-48, (2014).

25- Daoud, A.; Malika, D.; Bakari, S.; Hfaiedh, N.; Mnafgui, K.; Kadri, A. Assessment of polyphenol composition, antioxidant and antimicrobial properties of various extracts of date palm pollen (DPP) from two tunisian cultivars. *Arabian Journal of Chemistry*. . (2015). doi: 10.1016/j.arabjc.2015.07.014

26- Association of Official Analytical Chemist (AOAC). Official methods of analysis (18^{th}ed.). Washington DC, USA, (2010).

27- Hunter, R.S. and Harold, R.W. The measurement of appearance. Hoboken, NJ: Wiley-Interscience, (1987).

28- Hamed, S., Elshafei, K., El-Sayed, H., Abo-Elwafa, G., Afifi, S. and Zahran, H., 2020. Formulation of multi-functional omega-3 oil rich microcapsules by spray drying methodology. Egyptian Journal of Chemistry, 63(12), pp.5117-5136

29- Nisha, P.; Abdul Nazar, P.; Jahamurthy, P. A comparative study on antioxidant activities of different varieties of Solanum melongena. *Food* and *Chemical Toxicology,* V (47):2640-2644, (2009).

30- Eun-ju, J.; Bae, M.; Jo, Y. and Lee, S. Antioxidant activity of different parts of eggplant. *Journal* of *Medicinal Plants Research*, V5(18):4610-4615, (2011).

31- Kumari, A.; Chawla, W. and Dhatt, A.S. Genotypic differences for anthocyanins in different parts of eggplant (*Solanum melongena* L.). *International Journal* of *Advanced Research* in *Biological Sciences*, V5(1):12-18, (2018).

32- Sadilova, E.; Stintzing, F.C. and Carle, R. Anthocyanins, colour and antioxidant properties of eggplant *(Solanum melongena* L.) and violet pepper (*Capsicum annuum* L.) peel extracts. Zeitschrift fur Naturforschung C, 61(7-8):527-535, (2006). http://dx.doi.org/10.1515/znc-2006-7-810. PMid: 16989312.» http://dx.doi.org/10.1515/znc-2006-7-810

33- Disotto, A.; Di-Giacomo, S.; Amator, D.; Locatelli, A. Vitalone, C.; Toniolo, G.; Rotino, R.; Scalzo, A.; Palamara, M.; Marcocci, and Nencioni, L. A polyphenol rich extract from solanum melongena L. dr2 peel exhibits antioxidant properties and anti. herpes simplex virus type 1 activity In vitro. Molecules, 23:1-25, (2018).

34- Peterson, J. and Dwyer J. Taxonomic classification helps identify Flavoidcontaininy food on a semiquntitative food frequency questionnaire. *Journal* of the *American Dietetic Association*, V (98):677-685, (1998).

.

35- Abozed, S.S., Elaraby, G.M. and Zahran, H.A., 2021. Application of Spray-dried Microcapsules of Purslane (L.) Seed Oil Enhances Quality of Mango Juice. The Open Agriculture Journal, 15(1)

36- Tharasena, B. and Lawan, S. Content of beta-carotene, xanthophyll, luten and zeaxanthin in vegetable as thai Side dish. *International*

Conference on *Nutrition* and *Food Science*, 39:244-248, (2012).

37- Lessoy, T.Z.; Micael, E.B.; Jean, T.G.; Betty, M.F. and Sebastien, L.N. Two novel non- conventional seed oil extracts with antioxidant and antimicrobial activities. *Tropical Journal* of *Pharmaceutical Research*, 11:469-475, (2012).

38- Čanadanović-Brunet, J.M.; Savatović, S.S.; Ćetković, G.S.; Vulić, J.J.; Djilas, S.M.; Markov, S.L. and Cvetković, D.D. Antioxidant and antimicrobial activities of beet root pomace extracts. *Czech Journal of Food Sciences*, 29(6): 575-585, (2011).

39- Nisa, A.; Saeed, K.; Hina, S.; Zahra, N.; Mazhar, S.; Kalim, I. and Syed, Q. Nutritional, antioxidant, microbiological and toxicological studies on red dye extracted from red beet roots (*Beta vulgaris*). *Research Journal* of *Chemical Sciences*, 5(4):1-6, (2015).

40- Leulescu, M; Andrei, R.; Pa, I.L.; Moant, A.; Cioatera, N.; Popescu5, M.; Morı, E.; Bubulica, M.V.; Florian, G.; Ana, H. and Rotaru, P. Tartrazine: physical, thermal and biophysical properties of the most widely employed synthetic yellow food-colouring azo dye. Journal of Thermal Analysis and Calorimetry, 134:209-231, (2018).

41- Abdo, E.M.; Shaltout, O.E.; Ali, S. and Mansour, H.M.M. A functional orange juice fortified with beetroot by-products attenuates hyperlipidemia and obesity induced by a high-fat diet. Antioxidants, 11(457):1-19, (2022).

42- Hosseini, S.; Gharachorloo, M.; BabakGhiassi-Tarzi, B. and Ghavami M. Evaluation of the organic acids ability for extraction of anthocyanins and phenolic compounds from different sources and their degradation kinetics during cold storage. *Journal* of *Food* and *Nutrition* Sciences, 66 (4):261-269, (2016).

43- Silva, T.M.; Marinoni, D. T.; Peano, C. and Roberta Giuggioli, N. A new sensory approach combined with a text-mining tool to create a sensory lexicon and profile of monovarietal apple juices. Foods, 8:608, (2019).

44- Pathare, P. B.; Opara, U. L.and Al-Said, F. A. Colour measurement and analysis in fresh and processed foods: A review. Food and Bioprocess Technology, 6:36-60, (2013).