Egypt. J. Food Sci. **Vol. 46,** pp. 91- 100 (2018)

Characterization of Wastes from Pomegranate (*Punica granatum* L.) Juice and Its Use as a Functional Drink

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FOUR Egyptian pomegranate cultivars (Edkawy, Manfaloty, Sahrawy and Wonderful) and juice extraction method (pressing halves of fruits and blending separated arils) on characteristics and utilization of juice extraction wastes were studied. The results showed significant variations in wastes yield and their content of bioactive compounds (total phenols, flavonoids, anthocyanins, tannins, proanthocyanidins), antioxidant activity and reducing power among cultivars, juice extraction method anddrying processes (vacuum and sun drying) and their interactions. Generally, Edkawy cultivar gave higher yield of waste rich in bioactive compounds, antioxidant activity and reducing power than other cultivars. Wastes prepared from blending fruit arils followed by vacuum drying had higher yields than that made by pressing halve of fruits and sun drying. Nine simple phenolic acids were identified and quantified by HPLC in Wonderful aril juice vacuum dried waste (gallic, ellagicchyrsin, protochatechuic, caffeic, ferulic, cinnamic, vanilic and syngic acids). This waste was also rich in dietary fiber at level of 58% total dietary fibers. The panelists accepted drinks made from pomegranate waste powder alone or in mixture with whole dried lemon fruits, rosella and/ or cinnamon powders at 1:1 (w/w) ratio. All drinks were rich in total phenolic content, antioxidant activity and reducing power.

Keywords: Antioxidant activity, Bioactive compounds ,Pomegranate cultivar, Wastes utilization.

Introduction

Pomegranate juice processing wastes include the seeds,outer peels (husks), rind membranes and piths of the fruit. The pomegranate seeds composed of nearly 27.2% fat, 13.2% protein, 35.2% crude fibers, 2% ash, 6% pectin, and 4.7% sugars (El-Nemr et al., 1990 and Adulse & Patil, 1995). They have considerable amounts of fatty acids, vitamins , polyphenols and rich in proteolytic enzymes.(Morton, 1987 and Dumlu & Gurkan, 2007). Seeds of Turkian Hicaznar pomegranate cultivar had 21% oil and 15 % protein on dry matter base. They were rich inmineral matters. (Golukci, 2014).

Pomegranate peels contained 15.56% protein, 1.3 % fat, 5.24% crude fiber, 50.84 mg vitamin C per 100g, 10 mg/ 100g calcium , 12 mg/ 100g magnesium, 36 mg/100 g phosphorus, 0.35mg / 100 g zinc, 3 mg/100g sodium, 236 mg/100g potassium and the following amino acids (g per 100 g) , 8.58 arginine, 8.20 histidine ,7.08 lysine, 11.19 aspartic, 19.4 glutamic and 15.2 glycine (FAO/WHO, 1973). It is also rich in antioxidant and has antiviral, anticancer properties and antitumor effects (Tyagi *et al*., 2012). Peel antioxidants are capable to protect low density lipoprotein (LDL) cholesterol against oxidation and reduce risk of cancer and heart disease(Madrigal-Carballo et al., 2009), and lower inflammation in the body. (Tyagiet al., 2012). Sayeeda et al. (2013) incorporated pomegranate peel powder in Idli flour at 10,15 and 20% levels. They found that the overall acceptability was higher for the 10% level of incorporation of pomegranate peel flour than the other prepared Idliproducts.In Northern India, pomegranate juice pith is sun dried for 10-15 days for use as a spice. It is rich in anthocyanins and known as Anaradana (Morton, 1987).

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Generally processing one ton of pomegranate fruits yields approximately from 322 to 341 liters of juice and generates about 669 kg of pomegranate by-products made of pith, rinds, and peels. In fresh weight, the peel and internal membranes of the pomegranate represents 50% (Hasnaoui et al., 2014). The overall objective of this study was to assess the potential of pomegranate juice extraction wastes as a functional food ingredient. Different cultivars and extraction methods were used to determine the least effect on bioactive compounds in the waste.

Materials and Methods

Ten Kg of pomegranate (*Punica granatum* L.) fruits at harvesting maturity from four cultivars, (Edkawy, Sahrawy , Manfaloty and Wonderful) each were purchased from a commercial fruits and vegetables market in Alexandria city , Egypt in August 2016. The fruits were transported to the Postharvest Technology Center, Faculty of Agriculture, Alexandria University, Egypt. Enveloped filter bags of roselle and cinnamon , low density polyethylene bags , empty enveloped filter bags and lemon fruits were purchased from the retail market. Alexandria , Egypt.

The following analytical grade chemicals were used in this study, gallic and ellagic acids, Folin-Ciocalteu's phenol reagent, cateckin,tannic acid and vanillin reagent of Sigma-Aldrich Company (St. Louis, Missouri, USA) ,HPLC grade O- phosphoric acid (85%), methanol and acetonitrile of Fisher Scientific Inc. (New Jersey, USA). The water used in HPLC analysis was deionized and filtered through a 0.45 µm type HA membrane filter. Syringe filters made of nitrocellulose (Millipore, Bedford, USA) or polytetrafluroethylene (Sartorious, Goettingen, Germany) with pore size of 0.45 µm were used to filter aqueous or organic extracts .

Technological Methods:

Preparation of Pomegranate juice extraction wastes:

Pomegranatejuice was extracted from either the whole fruit or the arils of 5 kilograms.The whole fruit juice was extracted by a hand presser after cutting into halves. Arils were manually separated after cutting the washed fruit into four pieces and removing the fruit peel and skin covering the arils. The separated arils were mixed in an electric mixer for 30 sec (Hmid et al., 2013). The wastes of the extracted juice of each of whole and arils of pomegranate fruits were separately collected, and cut into 3-5 mm small pieces by knives. Each type of wastes was divided into two portions before subjecting to sun or vacuum drying. Sun drying was carried out at 29-32^{o} C and 80-85% relative humidity for 5 days after filling in drying wire stainless steel drying trays and covered with clean muslin cloth to prevent contamination.Vacuum drying was performed at 60^{o} C for 48 hr using lab vacuum oven (Model 3618, USA). The dried products were ground to pass through 60 mesh sieve, packed in low density polyethylene bags, weighted to calculate yield and stored at 4^{o}C until used.

Preparation of pomegranate juice waste drink

Dried mixtures were prepared by mixing the under vacuum dried Wonderful pomegranate fruit juice wastes with each of the powders of whole dried lemon fruits , roselle leaves and inner cinnamon park at a ratio of 1:1 (w/w) in enveloped filter bags to prepare functional hot drinks. Each drink was prepared by pouring 100 ml of fresh boiling water over one enveloped filter bag (2 g) placed in a cup and allowed to infuse for 5 min. before drinking.

Chemical methods

Total phenolic (TP)content was assayed by Folin –Ciocalteu reagent with tannic acid as a standard (Singleton et al., 1965) . The reaction mixture was kept in dark at ambient temperature (22 ± 2 ^{o}C) for 2 hr. before measuring the absorbance at a wave length of 765 nm using UV-Vis. Spectrophotometer .The method described by Radunicet al. (2015) was employed to separate and determine simple phenolic acids with some modifications. The analytical equipment consisted of an Agilent Technologies 1100 series liquid chromatography (Agilent Technologies, CA, USA) equipped with solvent delivery system, photodiode array detector (CDAD, series G 1315 D) interfaced with an AC/DC convertor, auto sampler (series GI 329A) and HP chemstation (rev.B03.01) software package, a Rheodyne 7125 six way injector with 10 ml sample loap and an Agilent Zorbax eclipse XXDB reversed phase C18 (150 X 4.6 mm, particle size 5µm) analytical guard column. (Agilent USA). Extraction of phenolic compounds was done by weighing one gram of the under-vacuum dried pomegranate juice extraction wastes in quick fit conical flask, adding 20 ml of 2 M NaOH , flushing the flask with N_2 gas, replacing the stopper of the flask, shaking for 4 hr at 1200 rpm at room temperature (23 ± 2 ^{o} C) , adjusting the pH of sample to 2 with

6 N HCL , and centrifugation at 5000 rpm for 10 min.The phenolic compounds in the resulted supernatant were extracted twice with 50 ml of 1:1 (v/v) mixture of ethyl ether and ethyl acetate. The organic phase was separated in separated funnel, then concentrated under vacuum at 45 ^{o} C in a rotary evaporator , redissolved in 2ml ethanol, filtered through 0.45µm Millipore filter (Gelman, Laboratory, MI) and 50 µl of the obtained filtrate was injected onto HPLC. HPLC elution was carried out at room temperature (23 ± 2 ^{o} C) by solvent A (acetonitrile) and solvent B (acetic acid and water at a ratio of 2:98 v/v). The elution profile was at a flow rate of 0.8ml / min. with the following linear gradient program, 100 % B to 85% B for 30 min, 85%B to 50% B for 20 min, 50% B to 0% B for 10 min. and 0% A to 100% A for 10 min. The chromatogram was simultaneously monitored at 280 and 320 nm (with 2 nm band width) with spectra taken continuously through the elution. Calculation of concentration was based on the external standard method of an aqueous solution containing the following phenolic standards; gallic, protochatchuic, gentisic, chlorgenic, caffeic, syrngic, vanillic, ferulic, sinapic, ellagic,rosmarinic, cinnamic acids, catachine and chyrsin to fit a standard curve (peak area versus concentration in µg/g) with linear regression for each individual compound.

Total flavonoids content of the pomegranate wastes were determined spectrophotometrically at a wave length of 430 nm using UV-Vis Spectrophotometer as described by Hmidet al. (2013). The method is based on the formation of a complex of flavonoid- aluminum. Rutinwas used as a standard and the flavonoid level was expressed as mg of rutin equivalent per liter of juice. Total anthocyanins content of wastes was assayed with a pH differential method using 2 buffer systems; potassium chloride buffer of pH 1 (0.025 M) and sodium acetate buffer of pH 4.5 (0.1 M) as reported by Ozgenet al., (2008). Total proanthocyanidins content of dried wastes of pomegranate juice was determined as outlinedby Moyoet al. (2012). using vanillin reagent and measuring the absorbance at a wave length of 500 nm by UV-Vis Spectrophotometer (Laxco-Alpha-1102, Suite). Catechin was used as a standard and the final result was expressed as catechin equivalent. Total tannins content of pomegranate dried wastes of pomegranate juice extraction was colourimetrically estimated as tannic acid (AOAC 2000) .

Total , soluble (SDF) , insoluble (ISDF) , neutral (NDF) and acid detergent dietary fibers (ADF) were determined in fat extracted dried wastes of pomegranate juice extraction as mentioned in AOAC (2000).Pectin content of the dried pomegranate wastes was determined as calcium pectate after extraction , saponification with alkaline, precipitation by adding calcium chloride, washing until free from chloride ions, drying over night at 100^{o} C , cooling in a desiccator and weighting as pectate (Ranganna,1979). The following determinations were carried on drinks of functional pomegranate juice extraction wastes; pH by a digital pH meter after homogenization 2 ml of the drinks with 25 ml distilled water, titratable acidity as % citric acid by titration of the diluted homogenized drink with 0.1 M Na OH to an end point of pH 8.2, total phenolic content as mentioned above using Folin-Ciocalteu reagent, antioxidant activity by 2 procedures; ferric reducing antioxidant power (FRAP) of Jayanthi and Lalitha (2011) and evaluation of free radical scavenging effect on the 1,1 diphenyl-20 picryl hydrazine (DPPH) radical as described by Brand-Williams et al. (1995).

Sensory evaluation

Colour, appearance ,flavour and total acceptability of functional drinks were evaluated by randomly chosen twenty panelists of the members of the Food Science and Technology Department, Faculty of Agriculture, Alexandria University, Egypt. Numerical scoring test, five point scale was used, whereas; 5 means the best and 1 means the least as described by Piggott (1988).

Statistical analysis

The obtained data from this study were analyzed using software version 917 (stats soft, Inc. USA, 2003). Analysis of variance (ANOVA) was performed to determine the differences. Differences among means were considered significant at p0.05 < using Duncans,s multiple difference test (Steel and Torrie, 1980).

Results and Discussion

Yield and bioactive compounds of pomegranate juice extraction wastes:

Yields and bioactive compounds (total content of phenolic compounds, flavonoids, anthocyanins and tannins) of the juice wastes of the studied four pomegranate cultivars were reported in Table 1. The results showed that extraction method and cultivar of pomegranate fruits had significant

TABLE 1. Yield and content of bioactive compounds of juice extraction wastes of four pomegranate cultivars.

Methods of juice extraction	Pomegranate cultivars				Means
	Edkawy	Manfaloty	Sahrawy	Wonderful	
1-Waste yield %					
Halves fruits pressing	43.82±0.03	41.28±0.01	44.17±0.08	41.86±0.04	42.78 [a]
Arils blending	41.07±0.04	39.69±0.03	39.81±0.03	37.68±0.09	39.56 [b]
Means	42.44 [a]	40.48 [c]	41.99 [b]	39.77 [d]	
2-Total phenolic content (mg/g as tannic acid equivalent)					
Halves fruits pressing	11.84±0.03	6.56±0.01	4.98±0.02	9.94±0.09	8.31[b]
Arils blending	14.64±0.08	7.34±0.04	5.83±0.03	11.62±0.03	9.86 [a]
Means	13.24 [a]	6.95 [c]	5.36 [d]	10.78 [b]	
3-Total flavonoids (mg/g as rutin equivalent)					
Halves fruits pressing	0.64±0.01	0.23±0.02	0.17±0.004	0.35±0.01	0.35 [a]
Arils blending	0.66±0.02	0.24±0.01	0.19±0.004	0.34±0.02	0.36 [a]
Means	0.65 [a]	0.24 [c]	0.18 [d]	0.34 [b]	
4-Total anthocyanins (mg/g as cyaniding 3,5- glucoside equivalent)					
Halves fruits pressing	0.20±0.03	0.15±0.01	0.03±0.001	0.15±0.02	0.13 [b]
Arils blending	0.31±0.01	0.16±0.01	0.06±0.001	0.16±0.04	0.17 [a]
Means	0.26 [a]	0.15 [b]	0.05 [c]	0.15 [b]	
5-Total tannins (mg/g as tannic acid equivalent)					
Halves fruits pressing	10.66±0.06	0.60±0.02	0.40±0.06	0.84±0.04	3.125 [b]
Arils blending	12.69±0.01	0.67±0.08	0.41±0.01	0.97±0.03	3.685 [a]
Means	11.67 [a]	0.63 [c]	0.43 [d]	0.90 [b]	

Different letters in columns and rows indicate significant different values at $P < 0.05$.

effect on the yield and the bioactive compounds in the resulted juice wastes. Results of Akhtar et al. (2003), Ferial et al. (2014) and Ismail et al. (2014) showed that the juice yield of pomegranate fruits differed significantly among cultivars and also influenced by juice extraction method (2) Among the four studied cultivars, Edkawy fruits gave the highest yield of juice wastes followed by Sahrawy, Manfaloty and Wonderful accessions. The wastes of Edkawy, was the richest in bioactive compounds (total contents of phenolic compounds, flavonoids, anthocyanins and tannins) compared with the other studied cultivars. Fruits of Wonderful cultivar, contained more bioactive compounds than those of both Manfaloty and Sahrawycultivars, Waste from arils juice extraction gave the lower yield of wastes than the obtained from pressing the halves of pomegranate fruits and contained higher levels of bioactive compounds except for total flavonoids. The total flavonoid level did not differ significantly between the juice extraction methods. According to Mphahlele et al. (2016) the levels of polyphenols and hydrolysable tannins were higher in the extracted pomegranate juice from whole fruits than from arils due to migration of phenolic compounds from the outer parts of the fruits during pressing.

Based on the previous data, the resulted juice extraction wastes of Edkawy and Wonderful fruits cultivars were selected.

Effects of cultivar, extraction method and drying process on bioactive compounds in pomegranate wastes.

The analysis of variance of the influence of each of cultivar, juice extraction method, drying process and their interactions on bioactive compounds of pomegranate juice wastes (Table 2) showed significant differences in moisture content, total levels of phenolic compounds, flavonoids and tannins, proanthocyanidins concentration, antioxidant activity and reducing power of pomegranate juice processing wastes due to cultivar, juice extraction method, drying method and some of their interactions.Edkawy juice processing wastes contained relatively same moisture (14.50 %), and significant higher levels of total phenolic compounds (1147.52 mg/g as tannic acid equivalent) , flavonoids (52.15 mg/g as rutin equivalent), tannins (715.09 mg/g as tannic acid equivalent), and proanthocyanidins level (28.57 mg/g as quatchin equivalent) in addition to antioxidant activity as a reducing power (50.73%) than those of Wonderful one which were 14.25 %, 922.13 mg/g , 45.46 mg/g , 554.77 mg/g , 23.35 mg/g and 49.49% ,respectively.Extracting juice from arils by blending gave wastes lower in moisture values and higher in total content of phenolic compounds, flavonoids and tannins, proanthocyanidinslevel as well as antioxidant activity as a reducing power than that obtained from pressing halves of fruits.Vacuum drying technique lowered the moisture content and increased the total values of phenolic compounds, flavonoids and tannins, proanthocyanidins level in addition to antioxidant activity as a reducing power of the pomegranate juice processing wastes than sun drying. Significant effects were also found for interactions of cultivar, juice extraction method and drying process on moisture content of the pomegranate juice processing wastes, cultivar and drying process on the total phenolic compounds and reducing power of pomegranate juice processing wastes, cultivar and juice extraction method and drying process on total flavonoids content of pomegranate juice processing wastes and cultivar, juice extraction method on total tannins and proanthocyanidins of pomegranate juice wastes.

TABLE 2. ANOVA for the influence of cultivar, juice extraction method, drying process and their interaction on moisture and bioactive compounds of pomegranate wastes.

Source of variance	Mean square (MSS) of						
	Moisture content	**Total phenolic content**	**Flavonoids content**	**Total tannins content**	**Proantho-cyanidins content**	**Antioxidant activity**	**Reducing power**
• Cultivar	0.373 *	30806.107 **	268.46 **	154213.41 **	103.90 **	2.015 *	9.176*
• Juice extraction method	2.375 **	13713.342**	248.26**	3713.2*	61.95 **	18.85 **	84.84
• Cultivar-Juice extraction method	0.002 NS	280.372 NS	145.48**	5123.14*	1.87*	0.004 NS	0.47 NS
• Drying method	4.815**	2421083.861**	271.55**	209699.94**	354.66 **	35.84 **	54.59 **
• Cultivar-Drying method	0.005 NS	62964.746**	1.76 NS	156.51 NS	0.74 NS	0.34 NS	4.752 *
• Juice extraction method-Drying method	0.078 NS	280.65 NS	54.45 **	306.37 NS	0.12 NS	0.055 NS	0.821 NS
• Cultivar-Juice extraction method-drying method	0.537 *	280.37 NS	0.016 NS	709.48 NS	0.38 NS	0.004 NS	1.749 NS

Degree f freedom=1 NS: means not significant * Significant at 5% ** Significant at 1%

According to the above data, pomegranate juice processing wastes rich in bioactive compounds, high in an antioxidant activity and reducing power low in moisture can be prepared by blending arils and using the wastes of the cultivars containing high levels of bioactive compounds such as Edkawy and Wonderful after drying the wastes under vacuum. Souleman and Ibrahim (2017) found that pomegranate peels of Wonderful cultivar contained from 3.58 to 17.24 mg gallic acid equivalent per gram total phenolic compounds, and from 29.65 to 34.28 mg rutin equivalent per gram flavonoids on fresh weight.

According to Faten et al. (2016) Wonderful pomegranate cultivar gave higher yield of juice than Edkawy one. It is the predominant cultivar in juice processing plants in Egypt, therefore its juice wastes were used for the preparation of pomegranate waste drink. Its waste was prepared by vacuum drying after extracting the juice by blending the separated arils. Its wastes consisted of peels, rinds and piths.

Simple phenolic compounds

Table 3 gives the concentration (µg/ g) of the individual simple phenolic compounds identified in vacuum dried Wonderful pomegranate arils juice wastes. A total of 9 phenolic compounds were separated and identified in these wastes. These compounds arranged according to their concentrations in the following descending order as shown in Table 3.

The major simple phenolic compounds in this wastes were gallic acid and ellagic acid. According to Gumienna et al. (2016) ellagic acid is mainly found in sarcotestas of pomegranate seeds as it is water insoluble. It is antioxidant due to its ability to inhibit oxidation reactions and scavenge free radicals. It has a beneficial effect on human health. It has antimutagenic, antimicrobial and antioxidative properties. Both ellagic acid and gallic acid are the degraded products of punicalagin . According to Cam et al. (2014) pomegranate peels constitute approximately 40 % of the whole fruit and are rich in ellagic acid derivatives such as ellagitannins, punicalagin and punicalin. In addition to these type of polyphenols, the existence of caffeic acid, chlorogenic acid, p- coumaric acid, catechin, quercetin and rutin were identified in pomegranate peels by Lansky and Newman (2007). Zhou et al. (2008) found the following simple phenolic compounds in pomegranate peel extract by HPLC, caffeic acid, chlorogenic acid, p-coumaric acid, catechin, querectin and rutin.

Dietary fibers and pectin

Dietary fibers are important due to their functional properties, ability to hold water, and physiological effects in humans. Theyfacilitate food digest movement in intestine and reduces the incidence of colon cancer. As shown in Table 2, the total dietary fibers of the dried Wonderful pomegranate arils juice wastes was 58.12%. Hasnaoui et al. (2014) showed that the total dietary fibers content varied between 33.1 and 62.09% among the peels of 12 pomegranate cultivars. Viuda-Martos et al. (2010) reported that powder of pomegranate juice processing wastes have promising technological and functional properties that create new options for assessing this by-products.

TABLE 3. Phenolic compounds, dietary fibers and pectin content of Wonderful pomegranate juice wastes.

Compound	**Concentration**
Phenolic compound: (µg/g)	
1-Gallic acid	4416
2-Ellagic acid	1153
3-Chyrsin	68
4-Protochatchuic acid	56.53
5-Caffeic acid	23
6-Ferulic acid	16
7-Cinnamic acid	12
8- Vanillic acid	12
9-Syrngic acid	7
Dietary fibers: (%)	
Soluble fibers (SDF)	24.21
In soluble fibers (IDF)	33.91
Total dietary fibers (DF)	58.12
Neutral detergent fibers (NDF)	19.60
Acid detergent fibers (ADF)	17.80
Pectin (%)	4.26

The insoluble dietary fibers (IDF) to soluble dietary fibers (SDF) ratio is an important index for certain food applications. Spiler (1986) stated that an IDF/ SDF ratio from 1 to 2.3 is the most advantageous factor for the beneficial physiological effects associated with dietary fibers consumption. According to the results in Table 3, this ratio was 1.42. Viuda-Martos et al. (2012) found that the IDF / SDF ratio in pomegranate processing wastes ranged from 1.5 to 1.7. Hasnaoui et al. (2014) observed that this ratio differed from 0.92 to 1.29 in the dried powdered fruit peels of pomegranate from 12 cultivars.

Acid detergent fibers (ADF) give a good indication of the presence of cellulose and lignin, while neutral detergent fibers (NDF) gives a measure of total cell wall materials including pectin. The difference between NDF and ADF gives the insoluble hemicellulose. In this study, ADF and NDF contents were 17.8 and 19.6%, respectively. This means the presence of cellulose, lignin, pectin and hemicellulose in the pomegranate juice processing wastes. Lignin absorb bile acids and responsible for the hypo-cholesterolemic effect associated with fiber intake. Pomegranate wastes are also considered a potential source of pectin (4.26%). Hasnaoui et al. (2014) showed that the solid remaining after polyphenols extraction from pomegranate peels is rich in pectin , lignin and arabinoxylants. These biopolymers are important in chemical, food and pharmaceutical industries particularly when recovered from natural sources. Ibarz et al. (2006) stated that pectin is a complex mixture of polysaccharides containing units of galacturonic acid as the main compounds. It is a component of most fruits and also of dietary fibers.

Pomegranate waste-based drink

The results of the present study showed that pomegranate juice wastes are considerable potential source for phenolic, tannins, proanthocyanidins and flavonoids. The antioxidant activity and the reducing power of these wastes were mainly due to their content of such compounds. Gumienna et al. (2016) stated that pomegranate fruit is an ideal raw material for the production of functional foods.Therefore new polyphenol-rich drinks using a mixture of dried pomegranate juice processing wastes powder with each of dried lemon fruits, roselle, or cinnamon powders at a ratio of 1:1 w/w were prepared. The organoleptic properties ,titratable acidity , total phenolic content and antioxidant activity of these drinks were reported in Table 4. The panelists accepted the prepared four drinks. They preferred the odour of the drinks made up of 100% pomegranate juice wastes, and its mixture with either roselle or cinnamon than that with

TABLE 4. The sensory properties , pH, titratable acidity , total phenolic content and antioxidant activity of pomegranate juice waste-based drink.

Property	Type of drink			
	Pomegranate	Pomegranate-Lemon	Pomegranate-Roselle	Pomegranate-Cinnamon
Odour	4.5±0.52[a]	3.70±0.48 [b]	4.40±0.84 [a]	4.5±0.70 [a]
Taste	4.60±0.51 [a]	3.60±0.69 [b]	3.60±0.51 [b]	4.10±0.73 [a]
Acceptability	4.20±0.63 [a]	3.30±0.67 [b]	3.80±0.63 [a]	4.20±0.78 [a]
pH	5.76±0.22 [a]	2.90±0.10[c]	3.39±0.32 [b]	3.01±0.08 [b]
Total acidity (% as citric acid)	0.20±0.017 [c]	0.94±0.068 [a]	0.58±0.04 [b]	0.53±0.013 [b]
Total phenols (mg / 100 ml as tannic acid equivalent)	95.92 ±0.80[a]	50.53±2.43 [b]	45.82±0.92 [c]	52.75±0.80 [b]
Antioxidant activity:	38.86±0.26 [a]	24.53±0.26 [b]	17.30±0.63 [c]	24.70±0.20 [b]
1- Radical scavenging activity %				
2- Reducing power (as mmol Fe^{++} equivalent/ L)	2003.33±5.77 [a]	1821.33±2.30 [b]	1804.00±4.0 [c]	1792.00±8.00 [d]

Different letters in rows indicate significant different values at $P< 0.05$.

dried whole lemon fruit. They also preferred the taste of drinks made of 100% pomegranate and its mixture with cinnamon more than the other two products. Generally, no significant variation was detected in the overall acceptability of the drinks of 100% pomegranate wastes and its mixtures with roselle or cinnamon. On the other side, significant differences were observed in pH, acidity, total phenolic, antioxidant activity and reducing power among the four drinks. Among the four drinks; pomegranate-lemon one had the lowest pH and highest acidity while the 100% pomegranate wastes drink had the highest total phenolic content, antioxidant activity and reducing power. This was followed by pomegranate-lemon, pomegranate- cinnamon and pomegranate-roselle drinks. These results confirm the successful use of the dried pomegranate juice wastes, either alone or in mixtures with others natural drinks in preparing acceptable functional drinks rich in phenolic compounds, antioxidant activity and reducing power.

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(*Received*:6 / 8 /2018;
accepted:17/12/2018)

توصيف مخلفات عصير الرمان (*Punica granatum* L.) و إستخدامها كمشروب وظيفى

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أستخدم في هذه الدراسة أربع أصناف من الرمان المصرى (الإدكاوى ، المنفلوطى ، الصحراوى ، الوندرفول) و طريقتين لإستخلاص العصير (الضغط على أنصاف الثمار ، خلط الحبوب المفصولة منها) لدراسة الصفات و الاستفادة من مخلفات العصر. أشارت النتائج إلى وجود اختلافات معنوية في عائد مخلفات العصر و محتواه من المركبات النشطة حيوياً (المركبات الفينولية الكلية ، الفلافونويدات ، الانثوسيانينات ، التانينات، البروانثوسيانيدات) و النشاط المضاد للأكسدة و القدرة الاختزالية نتيجة لاختلاف الصنف و طريقة استخلاص العصير و نظام تجفيف مخلفات العصر (شمسى ، تحت تفريغ) و التداخل بينهم. فكان عائد مخلفات العصر الغنى في محتواه من المركبات النشطة حيوياً و العالى في النشاط المضاد للأكسدة و القدرة الاختزالية للصنف الإدكاوى عن بقية الأصناف الأخرى و عائد المخلفات الناتجة عن عصر الحبوب و المجفف تحت تفريغ أعلى من الناتج من عصر أنصاف الثمار و المجفف شمسياً. و تم عزل و التعرف على ٩ احماض فينوليةبإستخدام جهاز كروماتجرافيا السائل عالى الأداء من مخلف عصر حبوب صنف الوندرفول المجفف تحت تفريغ (حمض الجاليك ، حمض الإلاجيك ، حمض الكيرسك ، حمض البروتوكاتيكيورك ، حمض الكافييك ، حمض الفريوليك ، حمض السيناميك ، حمض الفانيليك، حمض سايرينجك) الغنى ايضاً في محتواه من الألياف الغذائية (٥٨٪) و تقبل المحكمون المشروبات الطبيعية المجهزة من هذا المخلف لوحده او بعد خلطه بنسبة ١:١ (وزن / وزن) مع كلاً من القرفه ، الكركديه ، مطحون ثنار الليمون الكامل الجاف و امتازت هذه المشروبات بارتفاع محتواها من المركبات الفينولية و النشاط المضاد للأكسدة و القدرة الأختزالية.