

PHYSICAL, CHEMICAL AND TECHNOLOGICAL STUDIES ON POMEGRANATE

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ABSTRACT

Pomegranate (*Punica granatum*) is cultivated in the tropical and subtropical areas and is widely distributed overall the world as well as Egypt. The edible part is the juicy seeds. This current study was carried out on Egyptian ripe pomegranate fruit (Wardi, Banati and Manfaloti varieties) season 1999, 2000 and aimed to study the physical characteristics and chemical composition of pomegranate fruit (juice, pomace and peel) for the three studied varieties. Results of this study showed that Wardi variety had the highest fruit weight (320 gm) followed by Manfaloti (260 gm). Pomegranate grains weight ranged between 48 – 63% of the total weight. Banati variety had the highest content of juice (42.9%), while that of Wardi and Manfaloti were (42.4 and 31.7%), respectively. (Pomace) pomegranate peel ranged between 37-52% of the total weight of the fruit.

Proximate chemical analysis of pomegranate fruit of the three varieties showed that: moisture ranged between 71-77% (grains), 85% (juice) and 80% (peels), while, crude protein content was in the range 8 – 9% (grains), 2.7 – 4% (juice) and 8.5 – 13% (peels). It was found also that, ash content was higher in the peels (3.8 – 5.3%) than juice (2.3 – 3%) and grains (2 – 2.5%). There was no lipids in pomegranate juice for the three varieties; while it was 2.3 – 4.2% in the grains and (1.7 – 3.8%) in the peels. The highest value of crude fiber content was found in the peels (17%) followed by (7 – 12%) in the grains and (0.8%) in the juice.

A remarkable variation among the varieties were observed for the acidity of the pomegranate juice. Manfaloti variety had the highest acidity (8%) followed by Wardi and Banati 3.1% and 2.4%; respectively, on dry base. PH value and TSS were ranged between (2.7 – 3.7) and (13%-17.3%); respectively. Ascorbic acid content of pomegranate juice was in the range 23.5 – 32.9 mg/100ml (on dry base). Banati variety was the highest whereas Manfaloti was the lowest.

A remarkable variations among the juice, pomace and the peels of the varieties of pomegranate in their content of pectin; it ranged between (2.0 – 2.2%) in the juice, (8.0- 8.3%) in the pomace and (24 – 28%) in the peels on dry wet basis. This mean that the pomegranate peels of the three varieties is a good source of pectin for various purposes. Tannin content was ranged between (2 – 4%) in the juice, (1 - 1.2%) in the pomace and (4.8 - 6.5%) in the peels meaning that the peels of pomegranate is a good source of tannins for the various purposes. Anthocyanin content determination showed that, Wardi pomegranate juice had the highest content of anthocyanin (120.7 mg / 100 ml) followed by Manfaloti (79.8 mg / 100 ml) and Banati (19.0 mg / 100 ml), on dry base. No trypsin inhibitor activity was detected for the juice, residua and peel of the three studied varieties.

The results we obtained revealed that pomegranate juice contain sensible amounts of sugars, ash, vitamin C and a good source of natural anthocyanin pigments. On the other hand the peels and seed residue of pomegranate contain good amounts of carbohydrate, fibers, pectin substances and tannins; meaning that it contain nutritional substances of healthy value.

INTRODUCTION

Pomegranate (*punica granatum* / Punicaceae) is one of the oldest known fruits cultivated in tropical and subtropical areas and widely consumed in many countries. In Egypt, it is grown in many parts extending from Aswan to Alexandria and the variations in the ecological range has an influence on characteristics of both tree and the qualities of the fruits as well (Ibrahim, *et al.*, 1985). The total annual production of pomegranate fruits in Egypt is about 23693 tons produced from about 4324 feddans (Anonymous, 1997.).

Pomegranate juice could be directly consumed as refreshing cold drink especially in summer and may be introduced in food industry to prepare pomegranate jam, marmalade, concentrated juice and jelly. Moreover, it could be use as natural colorant additive in food industry instead of artificial ones (Miskin and Saguy, 1982). Pomegranate peel contains some organic acid which could be used in drug manufacture such as gallic acid (Nasacheva *et al.*, 1973 and Khodzhaeva *et al.*, 1984).

Wide variations in the chemical composition of different types of pomegranate fruits were found by Onur and Kaska (1985).

Pomegranate fruit has not been the object of much scientific investigation and the fruits have not been subjected to many studies in Egypt, up to now. Very little information concerning its physical properties, chemical composition or its industrial utilization so, are present in the literatures therefore this study is mainly concerned with physicochemical characteristics of three varieties of pomegranate fruits cultivated in central and upper Egypt namely Wardi, Banati and Manfaloti and also the technology of pomegranate juice production.

MATERIALS AND METHODS

Materials: Three varieties of pomegranate fruit, namely; Wardi, Banati and Manfaloti, were used for the sake of comparison in this study. They were obtained from Alexandria whole sale local market (for Wardi variety) and from Abees farm (for Banati and Manfaloti varieties) during the winter season in 1999. They were selected at their ripe stage as could be judged by color and taste. The fruits were brought directly to the laboratory then washed thoroughly with water and peeled. The grains (arils) were separated manually by hand and packed in polyethylene pouches and then kept in a freezer at -18°C until use.

After thawing, the grains were quickly ground in an electrical molinex blender (Type 241, model Depose, made in France) at the maximum speed for juice extraction. The fresh juice was drained and screened through cheese cloth to separate the pomace. The peel from peeling and the pomace were dried over night at room temp. (22°C). The grains, fresh juice, pomace and peels were immediately selected to chemical analyses.

Chemical methods:

Methods: Moisture content, crude protein, ether extract, ash content, reducing and non-reducing sugars, ascorbic acid using 2, 6- dichlorophenol – indophenol dye as indicator, PH value, total acidity as grams citric acid / 100ml juice using sodium hydroxide (0.1 N) in the presence of phph as an

indicator and crude fiber were determined according to the method of A.O.A.C (1990).

Dietary fiber content was determined by the method of Goeing and Van Soest (1970) as modified by Baker (1977). Crude fiber, neutral detergent fiber (NDF), acid detergent fiber (ADF), insoluble hemicellulose (HC), cellulose, lignin, pectin, tannins, T.S.S and anthocyanin content were determined as described by Ranganna (1979). Trypsin inhibitor activity was determined using the method described by Kakade *et al.*, (1969).

The colour of the juice was determined by Lovibond Tintometer (model E, made by the Tintometer LTD Salisbury England), fitted with a 1 inch cell.

Technological methods:

The samples of pomegranate juice used in this study were prepared as follows: pomegranate grains were pre-heated to facilitate the extraction of the juice, pulped and filtered through cheese cloth. Preliminary work was carried out to determine the preferred juice sample of pomegranate juice as judged by the panelists. So, different juice samples containing 5 levels of TSS (16, 18, 20, 22 and 24%) were prepared at the pilot plant of Food Science and Technology Department, Alexandria University. Sugar solution of 80% concentration was used to reach this T.S.S. The samples were subjected to taste panel tests and it was found that the juice sample containing 22% T.S.S was the most preferable one among the other samples.

Sensory evaluation:

Sensory evaluation of different properties (colour, odour) taste, appearance and overall quality) of all treatments were evaluated by ten trained panelists of Food Science and Technology Department, Alex, Egypt, using composite scoring test according to Rangana (1979).

Statistical methods:

The organoleptic tests were analyzed statistically using ten replications for each treatment arranged in randomized complete block design. Analyses of variance treatment differences was preformed according to Steel and Torrie (1980). The data were analyzed on the PC-computer statistical analysis (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

1. Pomegranate fruit properties:

As shown in Table (1), the average weight, diameter and height of fruits were ranged from 250 - 320g, 8 - 9 cm and from 7 - 8.25cm, respectively for the three varieties. It can be seen that Wardi variety had highest average fruit weight and diameter, while Manfaloti variety was the highest in height comparing with the other varieties.

These results are in agreement with El-Nemr *et al.*, (1992) they reported that the average weight of pomegranate fruit was 284 g. Humedia and Hobani (1993) and Abd- El-Latif (2000) reported that the mean diameter and average weight of Banali and Manfaloti varieties were 7.99 cm and 200 g, respectively.

The percentage of grain, peel, juice and pomace (Table 1) ranged from (47.7 - 62.9%), (47.97 - 52.3%), (31.69 - 42.94%) and (9.6 -19.98%)

respectively, for the three varieties. Banati variety had the highest percent of grain (62.9%) and juice (42.94%), whereas Manfaloti variety had the lowest one.

Table (1): Technological properties of pomegranate fruit

Properties	Wardi	Banati	Manfaloti
Average fruit weight (gm)	320.00	250.00	260.00
Average diameter (cm)	9.00	8.00	8.75
Average height (cm)	8.00	7.00	8.25
Fruit weight composition (%)			
Peel	47.97	37.08	52.30
Grain (juice residue)	52.03	62.92	47.70
Grain	42.43	42.94	31.69
Pomace	9.60	19.98	16.01

These results are in agreement with El-Nemr *et al.*, (1992), they reported that peels and the grains of pomegranate were 38 and 52%, respectively. Abd- El - Latif (2000) reported that grains of Manfaloti variety represents about 70% of fruit weight while the juice represents about 66.70% of grains and 46.70% of the total weight of fruit.

2. Pomegranate juice properties:

Table (3) summarized the various characteristics of fresh pomegranate juice.

2.1. Color fresh pomegranate:

Colour of fresh pomegranate juice consisted of matching yellow, red and blue colour fractions. Red and blue represents the dominant colour while the yellow was the complementary one. Matching of red and blue gave a dark redish colour with some dullness of colour. Manfaloti variety had the highest value of red colour (5), whereas Banati variety had the lowest value (3.3).

2.2. Physicochemical properties:

The values of TSS and Refractive index (Table 3) were almost similar for the three varieties; it ranged from (13.0 - 13.7%) and (1.345 - 1.348%), respectively. Ibrahim *et al.*, (1985) reported that Banati, Wardi, Arabi and Hegazi pomegranate juice had 15.5, 12.5, 12.5, 14.7% TSS, respectively. Ibrahim (1989) stated that the pomegranate juice from Taiefi, Blahi and Baladi variety had 16.3, 14.1 and 12.2 TSS%, respectively. Bayindirli *et al.*, (1994) and Abd- El- Latif (2000) showed that pomegranate juice contained 15% TSS as average.

On the other hand, there were a remarkable variations in PH values of juice from the three varieties under study. Wardi variety had the highest value (3.65), whereas Manfaloti variety had the lowest (2.7), as shown in Table (3). Ibrahim *et al.*, (1985) reported that Banati, Wardi, Arabi and Hegazi

pomegranate juice had 2.72, 2.98, 3.59 and 2.78 PH values, respectively. Ibrahim (1989), Bayindirli *et al.* (1994) and Abd-El-Latif (2000) reported that the PH value of pomegranate juice was ranged from (3.1 - 6.1).

2.3. Chemical composition:

The results of chemical composition of fresh pomegranate (Table 2) showed a little differences in moisture content of extracted juice from Wardi, Banati and Manfaloti pomegranate varieties. It ranged from 85.00% to 85.24%. This results agreed with those of Bodur and Yurdagel (1986), also Abd - El - Latif (2000) stated that the moisture content of Manfaloti pomegranate juice was 79.5%.

Table (2): Physicochemical and chemical properties of pomegranate juice

Property	Wardi		Banati		Manfaloti	
1. Physical properties:						
Lovibond colour						
Red	4.300		3.300		5.000	
Yellow	1.700		1.500		1.600	
Blue	3.000		2.000		2.000	
2. Physicochemical properties:						
Total soluble solids (TSS)%	13.000		13.500		13.700	
Refractive index	1.348		1.348		1.345	
PH value	3.650		3.100		2.700	
3. Chemical composition:	W.B*	D.B**	W.B	D.B	W.B	D.B
Moisture	85.00	--	85.24	--	85.13	--
Crude protein	0.57	3.80	0.40	2.71	0.60	4.03
Total lipids	Nil	Nil	Nil	Nil	Nil	Nil
Ash	0.35	2.33	0.37	2.51	0.43	2.89
Carbohydrate ***	14.08	93.87	13.99	94.78	13.84	93.08
Total sugars %	12.05	83.33	12.86	87.13	11.67	78.48
Reduced sugars (RS) %	10.00	66.67	9.43	63.89	9.69	65.16
Non - reduced sugars %	2.50	16.66	3.43	23.24	1.98	13.32
Total acidity (TA) as citric acid %	0.46	3.07	0.35	2.37	1.19	8.00
R.S / T.A ratio	21.74	-	26.94	-	8.14	-
Crude fiber	0.13	0.87	0.11	0.75	0.13	0.84
Neutral detergent fiber (NDF) %	0.22	1.47	0.19	1.29	0.21	1.41
Acid detergent fiber (ADF) %	0.18	1.20	0.13	0.88	0.16	1.08
Hemicellulose content (HC) %	0.04	0.27	0.06	0.41	0.05	0.34
Cellulose content (CC) %	0.14	0.93	0.14	0.95	0.15	1.01
Lignin content (LC) %	0.08	0.50	0.05	0.34	0.06	0.40
Ascorbic acid (mg/100g)	4.42	29.47	4.85	32.86	3.49	23.47
Pectin %	0.32	2.13	0.33	2.24	0.30	2.02
Tannins %	0.31	2.07	0.33	2.24	0.58	3.90
Trypsin inhibitor %	-	-	-	-	-	-
Anthocyanin (mg/100g)	18.10	120.67	2.80	18.97	11.84	79.62

* W.B = Wet Base

** D.B = Dry Base

*** By difference

The juice of Manfaloti variety had the highest value of crude protein content (4.03%) followed by Wardi (3.80%) and Banati (2.71%) juice, on dry base. El-Nemr *et al.*, (1992) reported that pomegranate juice had 19.6 mg nitrogen /100 ml juice. No lipid content was found in the fresh juice of the three studies varieties as indicated in Table (2). Also, no references were found in this subject.

The ash content for the pomegranate juice varied according to the variety (Table 2). Manfaloti juice contained high amount of ash (0.43 & 2.89%) then Banati juice (0.37 & 2.51%) and Wardi juice (0.35 & 2.33%), on wet and dry base, respectively. These results were lower than the results reported by Wills *et al.*, (1986) where the ash content of pomegranate juice was 0.5% (on wet base), and higher than the results reported by El-Nemr *et al.* (1992) they reported that pomegranate juice contained 0.05% ash (on wet base).

Slight variations were observed in the carbohydrate content among pomegranate juice of the studied varieties, it ranged between 13.99 - 14.08% (on wet base). Ibrahim (1989) found that pomegranate juice (Taiefi, Blahi and Baladi varieties) contained carbohydrate in the range of 10.45 - 14.05% (on wet base).

The total sugars of pomegranate juice for the three studied varieties were also determined. It was found that Banati juice had the highest total sugars comparing with Manfaloti and Wardi varieties (Table 2). Ibrahim (1989) El-Nemr *et al.* (1992) and Abd- El-Latif (2000) reported that total sugars in pomegranate juice ranged from 10.45 - 14.90% (on wet base). On the other hand, the juice of Banati variety contained slightly lower amount of reducing sugars (9.43%) than that of Manfaloti juice (9.09%) and Wardi juice (10%), on wet base. These results are higher than those found by Ibrahim *et al.*, (1985) (7.4 - 9.6) and lower than those found by Ibrahim (1989) (9.77 - 10.84) and Abd-El-Latif (2000) (10.5 - 13.1), on wet base

The values of total acidity as citric acid (Table 3) of Manfaloti juice were the highest (1.19%) comparing with that of Wardi (0.46%) and Banati juice (0.35%), on wet base. These results are lower than those reported by Onur *et al.*, (1982) and Cemeroglu *et al.*, (1992). They reported that acidity of pomegranate juice lied between 0.07 - 4.98%. From the forementioned results it can be noticed that Banati juice had the highest value of total sugars and the lowest acidity.

The results of (RS / TA) for the different juices (Table 3) show that Banati juice had the highest value being 26.94 while manfaloti juice had the lowest (8.14).

Slight variation was found among the juice of the three varieties in crude fiber content (Table 3). Wardi had the highest amount of crude fiber (0.87%) followed by Manfaloti juice (0.84 %) and Banati (0.75%), on dry base. Ibrahim (1992) found that the crude fiber content of pomegranate juice (Manfaloti) was traces. Dietary fiber for the juice of the three studied varieties are presented also in Table 3. The result showed that neutral detergent fiber (NDF) and acid detergent fiber (ADF) values were the highest for Wardi and the lowest for Manfaloti. Slight variation was found in lignin content, and no observed difference was noticed in cellulose content, among the three varieties, while Banati had the highest amount in hemicellulose (0.41%).

Very slight differences were observed in ascorbic acid and pectin content among the three varieties. It were 3.49 - 4.85 mg ascorbic /100 g juice and 0.30 - 0.33% pectin, on wet base. Wills *et al.*, (1986), El-Nemr *et al.*, (1992) and Hamed (1999) reported that pomegranate juice contained 3.70 - 14 mg ascorbic /100 g, on wet base.

Table (3): Chemical composition of pomegranate grains, peels pomace for Wardi, Banati and Manfaloti

Variety	Grains									Peels									Residue									
	Wardi			Banati			Manf.			Wardi			Banati			Manf.			Wardi			Banati			Manf.			
	W.B*	D.B*	D.B*	W.B*	D.B	D.B	W.B	D.B	D.B	W.B*	D.B*	D.B	W.B	D.B	D.B	W.B*	D.B*	D.B	W.B*	D.B*	D.B	W.B	D.B	D.B	W.B	D.B	D.B	
Properties	76.68	-	71.05	-	70.98	-	79.82	-	79.38	-	80.60	-	79.38	-	79.38	-	79.38	-	79.38	-	79.38	-	79.38	-	79.38	-	79.38	-
Moisture	2.34	6.22	3.43	7.16	3.96	8.93	2.57	12.74	1.64	8.45	1.92	9.31	1.92	9.31	1.92	9.31	1.92	9.31	1.92	9.31	1.92	9.31	1.92	9.31	1.92	9.31	1.92	9.31
Crude protein	1.39	2.27	1.94	3.28	2.41	4.23	0.76	3.77	0.50	2.58	0.35	1.70	0.35	1.70	0.35	1.70	0.35	1.70	0.35	1.70	0.35	1.70	0.35	1.70	0.35	1.70	0.35	1.70
Total lipids	0.40	2.10	0.49	2.11	0.52	2.48	1.05	5.20	1.01	5.23	0.79	3.85	0.79	3.85	0.79	3.85	0.79	3.85	0.79	3.85	0.79	3.85	0.79	3.85	0.79	3.85	0.79	3.85
Ash	19.19	89.41	23.09	87.45	22.13	84.36	15.80	78.29	16.25	83.74	17.56	85.14	17.56	85.14	17.56	85.14	17.56	85.14	17.56	85.14	17.56	85.14	17.56	85.14	17.56	85.14	17.56	85.14
Carbohydrate																												
Crude fiber and fiber analysis %																												
Crude fiber	3.85	6.95	7.07	11.91	6.64	12.07	3.38	16.75	3.32	17.11	3.48	16.88	3.48	16.88	3.48	16.88	3.48	16.88	3.48	16.88	3.48	16.88	3.48	16.88	3.48	16.88	3.48	16.88
Neutral detergent fiber (NDF)	5.81	10.59	10.07	17.62	9.10	16.66	3.23	6.02	4.15	21.37	5.80	28.13	5.80	28.13	5.80	28.13	5.80	28.13	5.80	28.13	5.80	28.13	5.80	28.13	5.80	28.13	5.80	28.13
Acid detergent fiber (ADF)	3.62	6.76	6.09	10.39	5.82	10.74	2.22	11.01	2.50	12.90	3.17	15.37	3.17	15.37	3.17	15.37	3.17	15.37	3.17	15.37	3.17	15.37	3.17	15.37	3.17	15.37	3.17	15.37
Hemicellulose content (HC)	2.20	3.83	3.98	7.23	3.28	5.92	1.01	5.01	1.65	8.50	2.63	12.76	2.63	12.76	2.63	12.76	2.63	12.76	2.63	12.76	2.63	12.76	2.63	12.76	2.63	12.76	2.63	12.76
Cellulose content (CC)	4.18	7.54	7.24	12.67	6.98	12.73	2.08	10.32	2.09	10.80	4.80	23.28	4.80	23.28	4.80	23.28	4.80	23.28	4.80	23.28	4.80	23.28	4.80	23.28	4.80	23.28	4.80	23.28
Lignin content (LC)	1.60	3.00	3.15	5.48	2.12	3.69	1.15	5.70	2.07	10.70	1.00	4.85	1.00	4.85	1.00	4.85	1.00	4.85	1.00	4.85	1.00	4.85	1.00	4.85	1.00	4.85	1.00	4.85
Pectin %	-	-	-	-	-	-	5.12	25.37	5.50	28.35	5.00	24.25	5.00	24.25	5.00	24.25	5.00	24.25	5.00	24.25	5.00	24.25	5.00	24.25	5.00	24.25	5.00	24.25
Tannins %	-	-	-	-	-	-	1.10	5.46	0.94	4.84	1.33	6.45	1.33	6.45	1.33	6.45	1.33	6.45	1.33	6.45	1.33	6.45	1.33	6.45	1.33	6.45	1.33	6.45
Trypsin inhibitor %	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Davey *et al.*, (2000) and Perez - Vicente *et al.* (2002) reported that, pomegranate juice could be a complementary source of ascorbic acid comparable to other fruits such as Apples, Carrots, Charries or Peaches and better than Plums or Pears. Cemeroglu *et al.* (1992) and Ibrahim (1992) found that pomegranate juice had 0.02 - 0.6% pectin (on wet base).

Tannin content in the three varieties under investigation (Table 3) varied between 0.31 - 0.58% compared with 250 mg /100 ml reported by Cemeroglu (1977). The data presented in Table 3 indicated also that pomegranate juice is free from trypsin inhibitor activity.

Wardi juice (Table 3) had the highest amount of anthocyanine pigments (18.1 mg /100 g juice) followed by Manfaloti juice (11.84 mg /100g) and Banati juice (2.80 mg /100 g). Bayindirili *et al.* (1994) and Abd-El-Latif (2000) reported that the anthocyanines concentration in pomegranate juice were 46.25 mg anthocyanin / L and 15.87 mg /100 g juice respectively. Abd-El-Latif (2000) reported that Manfaloti juice has 15.87 mg /100 gm juice, on wet base.

The data given in Table (2) show the chemical composition of pomegranate grains, peels and pomace for Wardi, Banati and Manfaloti. The data indicate that the grains of Manfaloti was slightly higher in moisture and lipid content than that of the other varieties. Manfaloti grains had the highest content of crude protein (29%) followed by Banati (7.2%) than Wardi (6.22%), on dry base. These results agreed with those, of El-Nemr *et al.*, (1992).

Slight variation were also observed among the grains of the three varieties in their contents of ash and carbohydrate; Wardi had the highest value of carbohydrate followed by Banati then Manfaloti.

Slight variations were observed among the peel of the three varieties (Table 2) in their contents of moisture, total lipids, ash and carbohydrate. The peel of Wardi had the highest value of crude protein content (12.74%) followed by Manfaloti (9.31%) then Banati (8.45%), on dry base.

A remarkable variations were found among the grains of the three varieties in crude fiber and fiber analysis. The grains of Manfaloti had the highest amount of crude fiber (12.07%), while the grains of Wardi had the lowest value (6.95%), dry base. The grains of Wardi had the lowest values of NDF (10.6%) and HC (3.83%) whearase Banati had the highest values (17.62% and 7.23%; respectively). The same variations was found in ADF content, CC and LC where (e.g.) Manfaloti had the highest value (10.74%) whearase Wardi had lowest one (6.76%) (Table 2).

Slight variations were found among the peel of the varieties in crude fiber content (Table 2). It ranged between (1675....) on dry base. Ibrahim (1992) reported that crude fiber content of pomegranate peel was 10.10%, dry base. Dietary fiber and ADF had the same trend e.g., NDF and ADF were higher in Manfaloti (28.13% and 15.37) than Wardi (11% & 16.0%) respectively.

Peel of Manfaloti had the highest amount of HC (12.76%) compared with Banati (8.5%) and Wardi (5%). The highest amount of CC was in Manfaloti peel (23.28%) whearase Banati and Wardi had nearly the same content of CC. (Table 2).

Slight variations were found among the pomace of the varieties in crude fiber and fiber analysis including NDF, ADF, HC, CC and LC. (Table 4). El-said (1999) stated that the value of dietary fiber of free fat Guava seed flour was 35.8 % NDF, 26.2% ADF, 14.7% CC, 9.62% HC and 11.5% LC.

Table (4): Mineral composition of pomegranate juice for the three studies varieties (as ppm)

Variety Mineral	Wardi		Banati		Manfaloti	
	W.B ^a	D.B ^b	W.B	D.B	W.B	D.B
Potassium	2700.00	18000.00	2000.00	13550.00	3000.00	20180.00
Sodium	165.00	1100.00	250.00	1690.00	215.00	1450.00
Calcium	383.00	2553.00	125.00	833.00	152.00	1013.00
Magnesium	96.00	640.00	28.00	190.00	68.00	457.00
Copper	10.50	70.00	10.30	70.00	8.10	54.50
Cadmium	ND	ND	ND	ND	ND	ND
Lead	ND	ND	ND	ND	1.00	6.70
Chromium	0.90	6.00	1.50	10.00	0.20	1.35
Nickel	1.30	8.70	1.00	6.80	1.60	11.00
Manganese	2.30	15.30	2.70	18.00	5.70	38.00
Iron	62.20	415.00	83.40	565.00	95.40	641.60
Zinc	126.00	840.00	32.00	217.00	123.70	831.90

^a Wet base

^b Dry base

ND = Non detectable

From the forementioned results (table 4), it could be seen that the pomace contained good amount of dietary fiber.

Very slight difference was noticed in pectin content among the peel and pomace of the three varieties. It ranged between 4.6 - 5.5%; on wet base. This means that filtration process used during juice preparation separated most of pomegranate pectin. Moreover, pomegranate peel had highest amount of pectin (Table 2) comparing to the juice (Table 3) and pomace (Table 2).

Ibrahim (1992) reported that pomegranate peel had 9.50% pectin; dry base. Siliba (1989) reported that pectin content of Mango peel was 14.0% , dry base.

From these results it could be concluded that, the by-products of pomegranate juice processing were a good source of pectin could be used for pectin production in large scale.

Table (2) showed that the peels had the highest amount of tannins (0.9 - 1.3%) followed by the pomace (0.65%) and finally the juice% (Table 3). These results are higher than the results reported by Cemeroglu (1977) and Ibrahim (1992); they reported that tannin content in pomegranate juice and peel were 250 mg /100 ml and 1.40%; respectively, on dry base.

Fortunately, the data presented in Table (2) indicated that the pomace and peels are free from trypsin inhibitor activity. Youssef (1999) (I and II) reported that the seeds of mango and peel of potato are free from trypsin inhibitor.

Table (5) show the mineral elements content of pomegranate fresh juice for the three studies varieties. The results indicated that there were great variations concerning most of the minerals in the extracted juice.

Generally, it is obvious that pomegranate juice is very rich in potassium, calcium, iron and zinc meaning that it is a good source of these very precious minerals for both children and adults. On the other hand the data represented in Table (5) showed that there was no cadmium, lead and very little concentration of chromium and nickel were found in all pomegranate juice samples which is good indication from the safety aspect point of view.

Table (5): Mineral composition of pomegranate pomace for the three studies varieties (as ppm)

Variety	Wardi		Banati		Manfaloti	
	W.B*	D.B*	W.B	D.B	W.B	D.B
Potassium	4840.00	8068.00	4810.00	8100.00	3740.00	6565.00
Sodium	20.10	33.50	20.80	35.00	31.10	54.60
Calcium	106.00	176.70	61.00	103.00	63.00	110.60
Magnesium	112.00	186.70	134.00	226.00	120.00	210.60
Copper	65.70	109.50	23.90	40.00	33.30	58.50
Cadmium	0.0024	0.004	ND	ND	ND	ND
Lead	0.90	1.50	ND	ND	ND	ND
Chromium	2.20	3.70	0.90	1.50	0.40	0.70
Nickel	1.20	2.00	1.90	3.20	2.30	40.00
Manganese	12.80	21.30	13.80	23.00	14.90	26.20
Iron	76.10	126.90	47.40	80.00	69.10	121.30
Zinc	77.00	128.00	36.80	62.00	37.70	66.20

* Wet base

† Dry base

ND = Non detectable

Manfaloti variety contained the highest levels of iron and potassium being 95.4 and 3000.0 ppm, respectively comparing with the other varieties. The same trend was also found concerning zinc concentration. These results agreed with that obtained by Ibrahim *et al.* (1989) and Cemeroglu *et al.* (1992) and disagree with El-Nemr *et al.* (1992). Wardi pomegranate juice had the highest concentration (383 ppm) of Calcium comparing with that of other varieties.

Ibrahim (1989) stated that the variations in mineral content among the different varieties could be due to the relative difference among their root systems to absorb the different elements at the same rate.

Table (6) show the amounts of minerals in pomegranate pomace for the three studied varieties. Potassium and sodium were ranged between (6565 - 8100) and (335 - 546) ppm, respectively. Copper, iron and zinc were ranged between (40 - 110), (80-127) and (62-128) ppm, respectively. El-Nemr *et al.*, (1992) reported that mineral composition of pomegranate seeds were 1.3 iron, 1.2 copper, 6.0 sodium, 12.4 magnesium, 45.2 potassium and 1.0 ppm zinc; respectively.

Mineral contents of pomegranate peel for the three studied varieties were also studied (Table 7). The data revealed that pomegranate peel contained good amounts of minerals, specially potassium, calcium, iron and zinc which means that the pomegranate peel is a good source of minerals, and so it can be use for animal feeding or any other purposes.

It can be conclude that these results are quite valuable due to the potential importance of the studied compounds in human health and relatively the high amount present in the juice. The obtained results indicate that

anthocyanins, other phenolic compounds and Vitamin C, all of which has anti-oxidant activity might contribute to protecting human from several diseases.

Table (6): Mineral composition of pomegranate peel for the three studies varieties (as ppm)

Variety Mineral	Wardi		Banati		Manfaloti	
	W.B [*]	D.B ^o	W.B	D.B	W.B	D.B
Potassium	6390.00	31660.00	6130.00	31600.00	6510.00	31570.00
Sodium	13.20	65.40	11.40	58.80	12.00	58.70
Calcium	99.00	491.00	105.00	541.00	255.00	1236.70
Magnesium	48.00	238.00	46.00	237.00	119.00	577.00
Copper	13.60	67.40	7.40	38.00	13.80	67.00
Cadmium	ND	ND	ND	ND	ND	ND
Lead	1.60	7.90	0.20	1.00	0.10	0.50
Chromium	8.80	43.60	1.30	7.00	14.20	68.90
Nickel	1.70	8.40	2.40	12.00	1.90	9.20
Manganese	7.70	38.20	6.30	32.00	6.70	32.50
Iron	84.20	417.60	46.70	241.00	56.50	274.00
Zinc	56.00	277.80	18.40	95.00	67.40	326.90

* Wet base

^o Dry base

ND = Non detectable

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دراسات فيزيائية ، كيميائية وتكنولوجية على الرمان

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تعتبر فاكهة الرمان من فواكه المناطق الاستوائية وشبه الاستوائية واسعة الانتشار في العالم وفي مصر ، للجزء المأكول منها هو الحبوب العسيرة . في هذه الدراسة والتي أجريت على ثلاثة أصناف مصرية من الرمان وهي الوردية ، البناتي والمنفلوطي موسم ١٩٩٩ تم دراسة الخواص الفيزيائية والكيميائية للعصير الخام والتفلة وكذلك القشور ، وقد لوضحت النتائج أن وزن الثمرة في صنف الوردية (١٢٠ جم) كان أعلى من المنفلوطي (٢٦٠ جم) يليه البناتي (٢٥٠ جم) ، وقطر وارتفاع الثمرة كان حوالي ٨ سم . أيضا تراوح وزن الحبوب بالنسبة للوزن الكلي ما بين ٤٨ إلى ٦٣% ، صنف البناتي احتوى أعلى نسبة من العصير (٤٢,٩%) مقارنة بالوردية والمنفلوطي (٤٢,٤ ، ٣١,٧%) بالنسبة للوزن الكلي للثمرة على الترتيب ، أما نسبة القشور فتراوحت ما بين ٢٧-٥٢% بالنسبة للوزن الكلي للثمرة .

وقد تراوحت قيم التحليل الكيموي التقريبي كالتالي :

نسبة الرطوبة للحبوب : ما بين (٧١-٧٧%) والعصير (٨٥%) والقشور (٨٠%) ، البروتين الخام في الحبوب : (٦-٩%) والعصير (٢,٧-٤%) والقشور (٨,٥-١٣%) ، والدهون في الحبوب : (٢,٢-٤,٢%) والعصير (صفر %) والقشور (١,٧-٣,٨%) والرماد في الحبوب (٢,٥-٢%) والعصير (٢,٢-٣%) والقشور (٣,٨-٥,٣%) ، الألياف الخام في البذور (٧-١٢%) والعصير (٠,٨%) والقشور (١٧%) على أساس وزن جاف .

احتوى عصير الرمان صنف منفلوطي على ٨% حموضة يليه صنف ودي ٣% ثم البناتي ٢,٤% على أساس وزن جاف ، وتراوح رقم pH مقدرة كحامض ستريك في العصير بين ٢,٧-٣,٧ والـ TSS حوالي ١٣% . واختلف العصير للأصناف الثلاثة في محتواه من حامض الاسكوربيك فأعلاهم صنف البناتي ٢٢,٩ ملجم / ١٠٠ مل يليه الوردية ٢٩,٥ ملجم / ١٠٠ مل ثم المنفلوطي ٢٣,٥ ملجم / ١٠٠ مل . وقد تفاوت محتوى العصير والتفلة والقشور للأصناف الثلاثة في محتواها من البكتين ، فهي (٢-٢,٣%) في العصير ، (٨-٨,٣%) في التفلة ، (٢٤-٢٨%) في القشور . وهذا يعني أن قشور الرمان تعتبر مصدر جيد للبكتين لأغراض مختلفة . وقد لوحظ أيضا تفاوت محتوى العصير والتفلة والقشور للأصناف الثلاثة في محتواها من التانينات فهي (٢-٤%) في العصير ، (١,٢-١%) في التفلة ، (٤,٨-٦,٥%) في القشور . وهذا يعني أن قشور الرمان تعتبر مصدر جيد للتانينات لأغراض مختلفة .

اختلف محتوى العصير للأصناف الثلاثة من الاثوسيانين فاعلى محتوى كان في صنف الوردية ١٢٠,٧ ملجم / ١٠٠ مل يليه المنفلوطي ٧٩,٦ ملجم / ١٠٠ مل ثم البناتي ١٩ ملجم / ١٠٠ مل .

لم يلاحظ أي نشاط لمثبط إنزيم التربسين في أجزاء الثمرة الثلاثة للأصناف موضع الدراسة . تشير النتائج أن عصير الرمان يحتوي كميات محسوسة من السكريات ، الرماد ، فيتامين ج . بينما تحتوي القشور والتفلة على كميات جيدة من الكربوهيدرات ، الألياف ، المواد البكتينية والتانينات أي أنها تحتوي على مركبات تغذية لها فوائد صحية هامة .