DRYING OF POMEGRANATE WASTES

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ABSTRACT

Samples of pomegranate peels and seeds were dried in laboratory dryer at different temperatures (70, 80, 90 and 100°C) and (50, 60, 70 and 80°C) respectively. The results indicated that drying took place in the falling rate period at all temperatures studied for all samples. Moisture transfer from pomegranate peels and seeds was described by applying the Fick's diffusion model, and the effective diffusivity was calculated. Effective diffusivity increased with increasing temperature. An Arrhenius relation with an activation energy value of 7189.282 kJ/mol. for pomegranate seeds and 11223.9for pomegranate peels. The effect of temperature on vitamin C,minerals and antioxidant was investigated

Keywords: Pomegranate Wastes, Drying, Effective Diffusivity, Chemical Analysis, Optimum Temperature

I. INTRODUCTION

Pomegranate (Punicagranatum L.) is an important fruit oftropical and subtropical regions. It is extensively cultivated inIran, Spain, Egypt, Russia, France, Argentina, China, Japan,USA, and in India. The edible part of the fruit (seeds-pulpbearing seeds) contains considerable amounts of acids,sugars, vitamins, polysaccharides, polyphenols and importantminerals [1]. However, the unattractive external appearance of a high percentage (~20%) of fruits precludes their fresh consumption [2]. The edible parts of pomegranate fruit represented 52% of total fruit weight, comprising 78% juice and 22% seeds. The fresh juice contained 85.4% moisture, 10.6% total sugars, 1.4% pectin, 0.1 g/100 ml total acidity (as citric acid). Meanwhile, the seeds are a rich source of total lipids, protein, crude fibers and ash representing 27.2, 13.2, 35.3 and 2.0%, respectively, and also contained 6.0% pectin and 4.7% total sugars. The iron, cupper, sodium, magnesium and zinc contents of the juice were lower than those of seeds, except potassium which was 49.2 ppm in the juice[3]. Pomegranates are a well-known source of many valuable substances, such as hydrolyzable tannins (punicalagins and punicalins) [4], condensed tannins (proanthocyanidins) organic acids (malic acid) [5], anthocyanins[6] and phenolic acids (gallic acid and ellagic acid) [7]. All these compounds show high antioxidant activity [8] and induce health benefits against cancer, cardiovascular diseases and other diseases [9]. Recently, pomegranate juice and even fermented pomegranate juice were demonstrated to be high in antioxidant activity [4 and 10]. Guo, et al., [11]found that pomegranate peel had the highest antioxidant activity among the peels, pulp and seed fractions of 28 kinds of fruits commonly consumed in China, as determined by FRAP (ferric reducing antioxidant power) assay. The seed and peel particles are considered as waste portion of pomegranate. Inedible portion of pomegranate also contain antioxidant, phenolic compounds and flavonoids in high quantities. Further it can be a god nutrient source. However, this waste portion has not been utilized in food industry. Drying of seeds is the most important process since it has a great effect on the quality of end product. Traditionally, in India, pomegranate is dried in the open sunlight [12]. The drying kinetics of food is a complex phenomenon and requires dependable models to predict drying behavior [13]. There are several studies describing the drying behavior of various fruits and vegetables. But, the information on drying kinetics of pomegranate appears to be very scanty. The objective of this paper is to investigate the drying behavior of pomegranate peels and seeds, also to study the effect of temperature on pomegranate wastes contents such as minerals, vitamins and antioxidant.

II. MATERIAL AND METHODS

2.1. Drying Procedure

Fresh samples of pomegranates collected from local market in Giza, Egypt. The drying experiments were carried out using a laboratory scale hot-air dryer installed in Department of Food Engineering and Packaging, Agricultural Research Center. Moisture content was measured according to the method ofSenadeera, et al., [14]. Pomegranate peels and seedsafter extraction of juicewere washed and spread as a thin layer in the dryer after stabilizing heated air at the desired temperature and constant velocity, Weight loss of samples was recorded at one hour intervals during drying until it reaches the equilibrium conditions.

2.2. Mathematical Modeling of the Drying Curves

Drying curves were fitted into the simple exponential model Eq. (1); simplifying the general series solution of Fick's second law generally leads to the model. The simple exponential model is the first term of a general series solution of Fick's second law[15]. It is generally assumed that the mechanism of moisture migration during thin layer drying of food materials is characterized by diffusion as described by Fick's second law of diffusion [12, 16-18].

$$MR = \frac{M(t) - M_0}{M_0 - M_e} = Ae^{-kt} \qquad (1)$$

Where, MR (moisture ratio) is the unaccomplished moisture change defined as the ratio of the free water still to be removed at time (t) to the total free water initially available moisture ratio.

M(t) is the moisture content at time t (kg water/kg dry matter).

M_e is the equilibrium moisture content (kg water/kg dry matter).

M_0 is initial moisture content (kg water/ kg dry matter).

A, k are constants of the model.

The diffusion based model is based on the assumptions that the system is isotropic (the diffusion properties are constant in all directions). The main advantage of Eq. (1) is in the fact that both coefficients A and k can be deduced by taking logarithms of both sides of the relation, thus linearizing it:

$$\ln(MR) = \ln(A) - kt \qquad (2)$$

Where, MR is the moisture ratio

A, k is a constant of the model

t is the time, min.

The values of the k coefficient obtained can be related therefore to the drying conditions if approximated with a simple Arrhenius-type equation, [19 and 20]

$$D = D_0 \exp^{\frac{-E_0}{RT}} \quad (3)$$

The coefficients of which can be easily obtained if linearized as:

$$\ln D_{eff} = \ln D_0 - \frac{E_0}{R}\frac{1}{T} \quad (4)$$

Where, D_{eff} is the effective diffusivity, m^2/min.

D_0 is the pre-exponential factor of Arrhenius equation, m^2/min.

E_a is the activation energy, kJ/mol

R is the gas constant, kJ/mol. K

T is the temperature, K

The A and D_0 coefficients can be related to the drying air conditions by applying regression analysis techniques. The above Eqs. (2) and (4) were applied to fit the drying data identifying the influence of the air temperature and velocity on the effective moisture diffusivity and the drying constants.

2.3. Chemical Analysis

DPPH Free Radical Scavenging Ability

The antioxidant capacity of samples against DPPH (2,2-diphenyl-l-picrylhydrazyl) free radical was evaluated according to Brand-Williams et al., [21] by dissolving DPPH in methanol, and the antioxidant activity measured by decrease in absorbance at 515 nm.

2.4. Determination of Vitamin C (Ascorbic Acid)

Samples were prepared according to the method described by Meléndez et al., 2004[22]. The chromatographic procedure used was based on the isocratic method reported by Lee, 1993[23].

2.5. Determination of Ash Content

Ash was determined by the standard procedures of the AOAC, 2000[24].

2.6. Determination of Minerals

Were determined using the flam photometer (Galienkamp, FGA, England) and perkin Elmer atomic absorption spectrophotometer (model 80, England) as described in A.O.A.C, 2005[25]

III. RESULTS AND DISCUSSION

3.1. Drying Of Pomegranate Wastes

Pomegranate peels and seeds were dried at different temperatures (70, 80, 90 and 100°C) and (50, 60, 70 and 80°C) respectively. The effect of drying temperature on vitamin C, minerals and antioxidant was studied. Figures (1 - 2) show the variation of moisture ratio with time at different temperature for pomegranate peels and seeds, The results show that drying took place in the falling rate period at all temperatures studied and liquid diffusion controls the processes, as previously mentioned that drying process of food materials mostly occur in the falling rate period, [26].

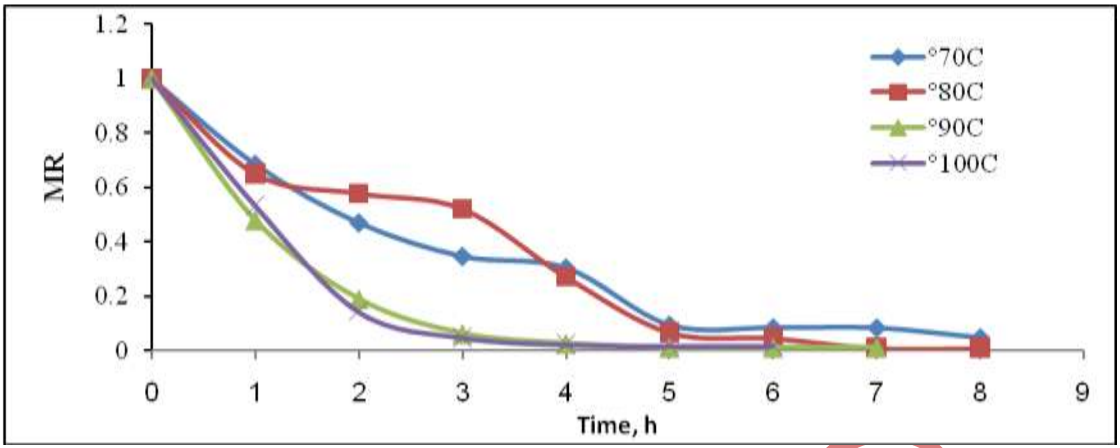

Fig.1 Effect of Time of Drying On Moisture Ratio at Different Temperatures for Pomegranate Peels

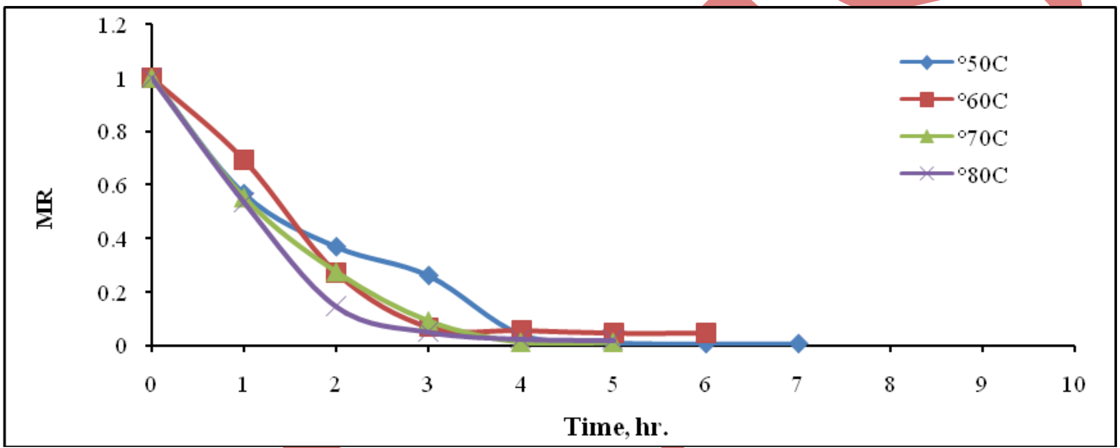

Fig. 2 Effect of Time of Drying On Moisture Ratio at Different Temperatures for Pomegranate Seeds

It is obvious from Figures (1 and 2)that increasing the drying temperature caused an important increase in the drying rate and the drying time is decreased. The time required for the moisture ratio to reach any given level was dependent on the drying conditions, being highest at 70ºC and lowest at 100ºC for pomegranate peels and highest at 50ºC and lowest at 80ºC for pomegranate seeds.

Effective diffusivities are determined by plotting experimental drying data in terms of ln(MR) versus time resulting in a straight line according to linear expression of Eq. (2), a plot ofln(MR) versus time gives a straight line with a slope (k) as shown in Figures(3-4).

$$k = \frac{\pi^2 D_{eff}}{L^2} \qquad (6)$$

Where,r is the thickness of pomegranate samples, m

D_{eff} is the effective diffusivity, m^2/min.

L is the thickness, m

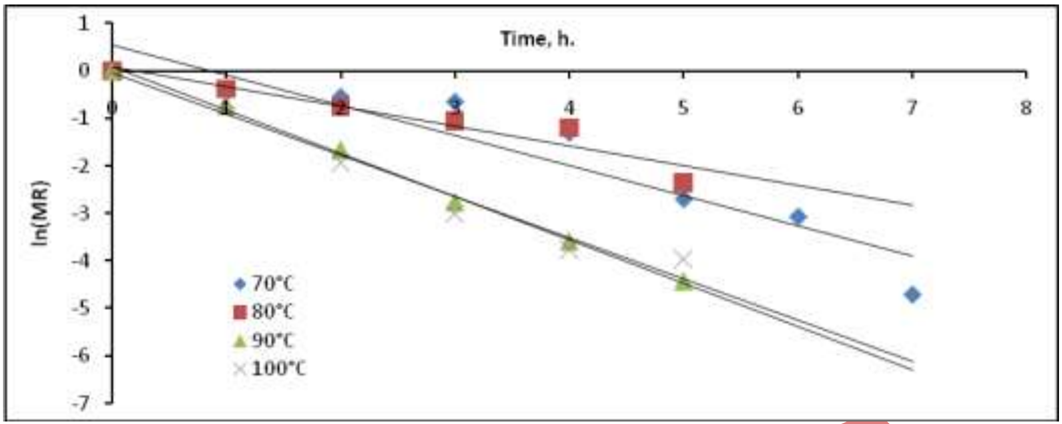

Fig. 3 Relation Between Logarithm Moisture Ratio And Time Of Drying At Different Temperatures For Pomegranate Peels.

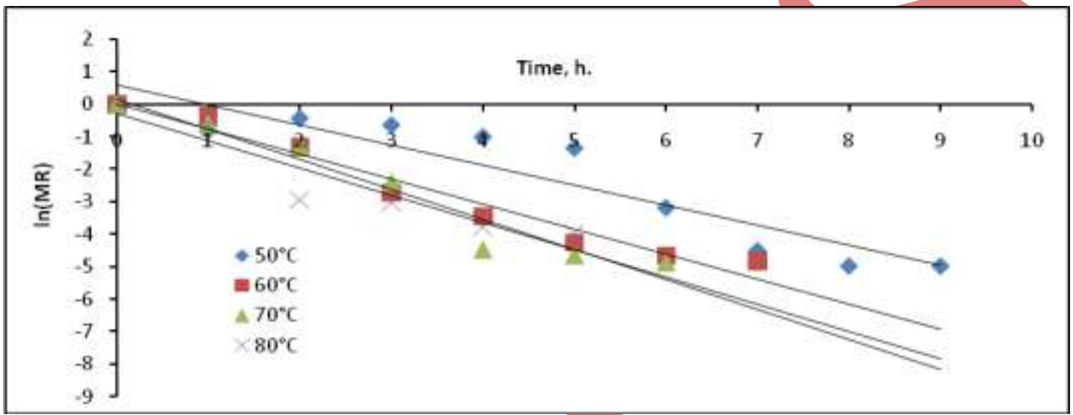

Fig. 4 Relation Between Logarithm Moisture Ratio and Time Of Drying at Different Temperatures for Pomegranate Seeds.

The determined values of D_{eff} for different temperatures are given in Fig. ., the effective diffusivities of pomegranate peels were 0.000103, 0.000106, 0.00012 and 0.000141 m^2/min. at 70, 80, 90 and 100 ºC respectively. The effective diffusivity of pomegranate seeds were 0.0001, 0.000122, 0.000127 and 0.000136 m^2/min. at 50, 60, 70 and 80 ºC respectively. The logarithm of the calculated effective diffusivities were plotted versus the reciprocal of the temperature Fig. 5, as viewed in Eq. (4), from the slope of the line the activation energy (E_a) was calculated, and constant D_0 as the intercept.The energy of activation was found to be 7189.282kJ/mol.for pomegranate seeds and 11223.9 kJ/mol. for pomegranate peels.

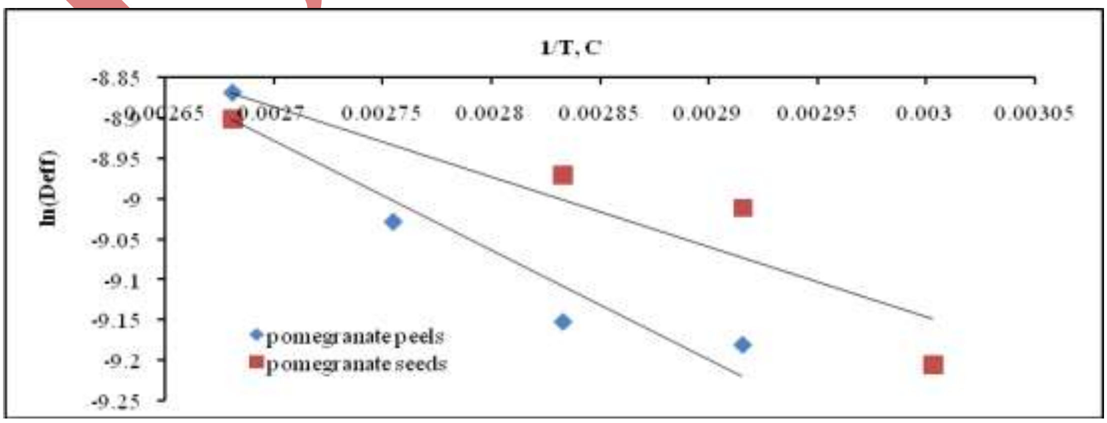

Fig.5 Arrhenius-Type Relationship Between Effective Diffusivity and Temperature

3.2. Chemical Analysis

3.2.1. Antioxidant Activity

Temperature is one of the most important factors affecting antioxidant activity. Generally, heating causes an acceleration of the initiation reactions, and hence a decrease in the activity of the present or added antioxidants [27].Pomegranate seedsand peels contain many different kinds of antioxidants, including those possibly not so far well characterized [4].It has been widely accepted that radical system used for the antioxidant evaluation may influence the experimental results [28]. In this study antioxidant capacity was measured by the scavenging capacity against DPPH at different drying temperature for both fresh pomegranate peels and seeds. The results showed that lower antioxidant activity was obtained for dried samples compared to the fresh products the antioxidant activity was 90.22% and 91.83% for fresh peels and seeds pomegranate samples respectively. Furthermore, the antioxidant activity contain was collapse from 90.22 to 50.4% in fresh and driedpeels respectively, while in driedseeds antioxidant activity decrease was not observed as shown in tables (1 and 2)as previously described by Yanishlieva, 2001[29] who stated that the variations in temperature may change the mechanism of action of some antioxidants or affect them in another way.

Table (1) Antioxidant Activity for Fresh and Dryed Pomegranate Peels at Different Temperatures

Treatments	Antioxidant activity %
Fresh	90.22
At 70˚C	56.9
At 80˚C	54.0
At 90˚C	51.7
At 100˚C	50.4

Table (2) Antioxidant Activity for Fresh and Dryed Pomegranate Seeds at Different Temperatures

Treatments	Antioxidant activity %
Fresh	91.83
At 50˚C	91.43
At 60˚C	90.02
At 70˚C	88.84
At 80˚C	87.9

3.2.2. Vitamin C (Ascorbic Acid)

The effect of hot-air drying temperature on vitamin C content of pomegranate peels and seeds were determined. It was found that vitamin C was affected by drying temperature.Vitamin C for fresh pomegranate peels and seeds were 1.44mg/100g, 0.16mg/100g respectively.Vitamin C content in both peels and seedsincreased with increasing temperature and after certain temperature it begins to decrease. The optimum temperatures were 90°C for pomegranate peels and 70^{o}C for seeds that keeps higher content of vitamin C, as shown in figures (6-7)

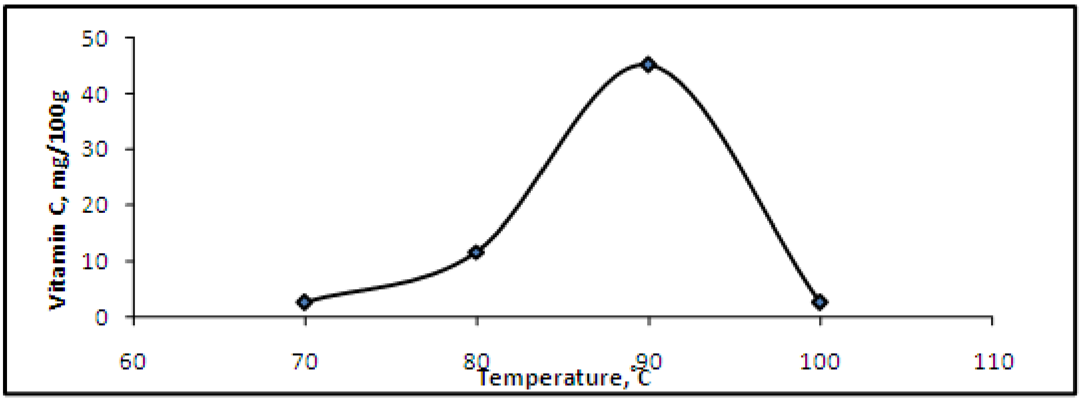

Fig. 6 Degradation of Vitamin C with Temperature for Pomegranate Peels

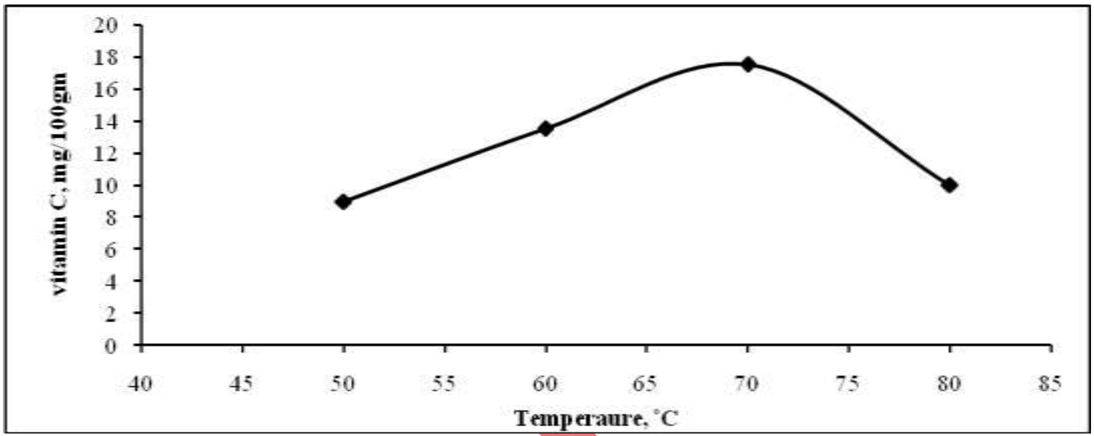

Fig. 7Degradation of Vitamin C with Temperature for Pomegranate Seeds

3.2.3. MINERALS AND ASH

Samples of dried pomegranate peel and pomegranate seeds at different temperatures with regards to their minerals content and ash content were evaluated and the obtained results are recorded as in Tables (3-4). The results showed that pomegranate peels and seeds contain ash, Fe, Ca and Zn at all temperature studied, ash content reached its higher value in dried pomegranate peels (5.5%) at 80°, while ash content decreased with increasing temperature for dried pomegranate seeds.Dried pomegranate seeds have higher content of Fe and Zn than dried pomegranate peels, while pomegranate peels has higher content of Ca than pomegranate seeds at all studied temperature, as previously discussed by the work of Ullah, et al., 2012, Dadashi, et al., 2013 and Almeida &Vasconcelos, 2003 [30-32] for different pomegranate varieties. Fresh sample of pomegranate peels contains ash (8.1%), Fe (2.3 mg/100gm), Ca (162.1 mg/100gm) and Zn (0.84 mg/ 100g), fresh pomegranate seeds contains ash (6.9%), Fe (18.7 mg/100gm), Ca (56.3 mg/100gm) and Zn (1.67 mg/100g).

Table (3)

Minerals and Ash Contents in Fresh and Dehydrated Pomegranate Peels Atdifferent Temperatures

Treatments	Ash%	Fe (mg/100g)	Ca (mg/100g)	Zn (mg/100g)
Fresh	8.1	2.3	162.1	0.84
70˚C	5.1	24.8	104.6	1.8
80˚C	5.5	24.7	56.7	1.45
90˚C	5.4	34.8	46.6	1.3
100˚C	5.0	39.8	101.7	3.7

Table (4) Minerals and Ash Contents in Fresh and Dehydrated Pomegranate Seeds at Different Temperatures

Treatments	Ash%	Fe (mg/100g)	Ca (mg/100g)	Zn (mg/100g)
Fresh	6.9	18.7	56.3	1.67
50°C	5.4	35.4	100.4	8.22
60°C	5.2	30.3	59.48	6.29
70°C	4.9	41.56	63.21	3.7
80°C	4.9	74.24	82.84	4.26

IV. CONCLUSION

The effect of hot air drying temperature on pomegranate peels and seeds contents (vitamin C, antioxidant, ash and minerals) were determined. It was found that the optimum temperatures were 90°C for pomegranate peels and 70C for seeds that keeps higher content of vitamin C.The results showed that lower antioxidant activity was obtained for dried samples compared to the fresh products the antioxidant activity was 90.22% and 91.83% for fresh peels and seeds pomegranate samples respectively. Furthermore, the antioxidant activity contain was collapse from 90.22 to 50.4% in fresh and dried peels respectively, while in dried seeds antioxidant activity decrease.Pomegranate peels and seeds contain ash, Fe, Ca and Zn at all temperature studied, ash content reached its higher value in dried pomegranate peels (5.5%) at 80°, while ash content decreased with increasing temperature for dried pomegranate seeds. Dried pomegranate seeds have higher content of Fe and Zn than dried pomegranate peels, while pomegranate peels has higher content of Ca than pomegranate seeds at all studied temperature

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