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Original Article

Evaluation of Antioxidant and Free Radical Scavenging Activities of Pattypan Squash Fruit and Skin Extracts and Effect of Osmotic Pretreatment on Improving Its Drying By Hot Air

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Abstract

This paper was aimed to study total phenolic content (TPC) and free radical scavenging activity of fruit extract (FE) and fruit skin extract (FSE) of pattypan squash, and to evaluate the effects of type of osmotic solution and dehydration time on mass transfer process during dehydration pattypan squash and determine the optimum condition of this pre-treatment. type of osmotic solution and dehydration time had significant effect on water loss (WL), solid gain (SG), weight reduction (WR), acidity, shrinkage, and rehydration of the dehydrated samples. TPC and free radical scavenging activity of pattypan squash extract were increased by increasing concentration of extract. The sample dehydrated with sucrose+salt solution had the highest WL and WR. Treatment with sucrose+salt solution can be select as an osmotic dehydration pretreatment for drying pattypan squash, because of short dehydration time and low shrinkage and desirable sensorial properties of dried product.

Key words: Total phenolic content, Free radical scavenging activity, Pattypan squash, Osmotic dehydration

INTRODUCTION

Nowadays, using various synthetic compounds as preservative is one of the important problems of food industry, which their potential risks on human health have been proven. Therefore, the investigation on natural antioxidants sources is necessary in order to replace the synthetic types (Salminen et al., 2008).

Pattypan squash (cucurbita pepo varclypeata) is one of the summer squash varieties. Its fruits have spherical appearance and bright green to orange in color after reaching. It is one of the oldest species squash, which is native to south Ocampo, Tamaulipas, Mexico. Squash is rich in carotenoids, A, E and C vitamins (Piasecka-Jóźwiak et al., 2013).

Fruit wastes there are because of the lack of adequate facilities for handling, transporting, storing fruits in developing countries. These wastes are estimated to be more than 30% -40%. In addition to physical and economical damages, loss of nutrients such as vitamins and minerals from nutritional aspect is very important. Therefore, the reducing post-harvest damages of agricultural products by appropriate storing methods will have a significant impact on economy (Kader and Rolle, 2004). Drying is one of these methods, which has the most using and economic efficiency. However, this method has several disadvantages such as loss of nutrition value, shrinkage, apparent density increasing, and high-energy consumption (Barbanti et al., 1994; Saurel et al., 1994).

Osmotic dehydration (OD) is a process in which water of food by hypertonic solutions such as sugar (glucose, fructose, and

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sucrose), sugar alcoholic (sorbitol and glycerol) and/or salt is removed, which is used as a pretreatment to improve quality of drying process. OD is performed as a pretreatment before air-drying, freeze-drying, freezing, and vacuum drying (Rostogi and Raghavarao, 2004). The rate of water efflux from food to osmotic solution is dependent to several factors such as, the solution concentration and temperature, size of food pieces, and the solution to food proportion (Raoult-Wack et al., 1992).

Thus, this paper was aimed to study total phenolic content (TPC) and free radical scavenging activity of fruit extract (FE) and fruit skin extract (FSE) of pattypan squash, and to evaluate the effects of osmotic solution type and dehydration time on mass transfer process during dehydration pattypan squash and determine the optimum condition of this pre-treatment.

MATERIALS AND METHODS

Materials

Pattypan squash was purchased from local market of Tehran (Iran) and stored at 4 °C to decrease the biologic and respiratory activities until using. Citric acid, NaCl, sucrose were prepared from Merck (Germany) company. All solvents and chemicals employed in this research were analytical reagent grade.

Pattypan Squash Extract (PSE) Preparation

In order to extract PSE, 6 g fruit and 7 g fruit skin were solved in 60 and 70 mL methanol (10% w/v) at 250 rpm and room temperature on hot plate for 24 h. After filtration through Whatman filter paper NO.1, the filtrate was concentrated using rotary evaporator (Laborata, model 400) at 35 °C and followed by drying in vacuum oven at 40 °C to remove solvent and produce powder.

Chemical Analyses of Pattypan Squash Extract (PSE)

Total phenolic content (TPC) was measured spectrophotometrically by Folin-Ciocalteau reagent using the method depicted by Kukić et al. (2008). A calibration curve of gallic acid in methanol was performed in the concentration range of 0.04– 0.40 mg/mL.

Free Radical Scavenging Activity

Evaluation of antioxidant activity was done based on 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) scavenging activity. Briefly, 50 µL of different concentrations of the extract solved in methanol were added to 2 mL of DPPH solution (0.004%). After incubation at room temperature for 90 min, the absorbance was spectrophotometrically measured at 517 nm.

The inhibition activity was calculated by the following formula (Kurniawati et al., 2007).

$$\%\text{inhibitory} = \frac{[DPPH]0 - [DPPH]S}{[DPPH]0} \times 100$$

[DPPH]0: Initial DPPH concentration

[DPPH]S: Final concentration of remaining DPPH

Osmotic Dehydration and Complementary Drying

In this study, the osmotic dehydration was used as pretreatment before complementary drying. Sugar-salt 35% (30% sugar+ 5% salt), sugar-acid (30% sugar+ 3% citric acid), and sugar 30% were used as osmotic solutions.

The temperature of dehydration process was considered constant at room temperature (25 °C). The fruit to osmotic solution ratio was considered 1:4. After dehydration process, squash pieces (1 cm in diameter) were washed by deionized distilled water and placed onto filter paper (Whatman) to absorb surface water. Complementary drying of squash pieces was performed in hot air dryer equipped with an air circulation fan at constant temperature (70 °C) (Seiiedlou et al., 2010).

Moisture Content

Primary moisture was measured using the method of AOAC 1990. Briefly, the samples were placed in oven (memmert oven model uf55) to achieve a constant weight at 105 °C for 24 h.

Related Equations and Parameters Calculating

The weight reduction (WR), water loss (WL), solid gain (SG), and coefficient of efficiency (WL/SG) values were calculated by the following formula after weighing at different stages (before osmotic dehydration (OD), after OD, and after drying in oven):

$$WL = \frac{(m_0 \times x_{w0}) - (m_t \times x_{wt})}{m_0} \quad (1)$$

$$SG = \frac{(m_t \times x_{st}) - (m_0 \times x_{s0})}{m_0} \quad (2)$$

$$WR = (mo - m1/mo) \times 100 \quad (3)$$

$$Pr = \frac{WL}{SG} \quad (4)$$

m0: primary weight of apple slices
m1: weight of apple slices after dehydration
xw0: primary moisture of apple slices
xwt: moisture of apple slices after dehydration
xs0: primary dry matter of apple slices (xs0 = 1- xwo)
xst: dry matter of apple slices after dehydration (xst = 1- xwt)

Shrinkage Measurement

The shrinkage (SKG) value of was measured by the following formula (Sioholm and Gekas, 1995):

$$\%SKG = \frac{V_0 - V}{V_0} \quad (7)$$

V0: volume of the fresh apple slices (cm3)
V: volume of the dried apple slices (cm3)

Rehydration

At first, the samples were drenched in distilled water for 3 h and then the rehydration was measured based on weight increasing compared to the sample before drenching (Hammami et al., 1999).

Acidity

Acidity was studied by titration and the following formula:

$$\text{Acidity (g)} = \frac{V \times 134.087 \times N \times 100}{2000 \times W} \quad (8)$$

Sensory Evaluation

The sensory properties of the samples, namely appearance (color), flavor, texture, and overall acceptability were evaluated by 20-member trained panelists (9 females and 11 males) took part in the descriptive analysis. The evaluation was performed in a climate-controlled sensory evaluation laboratory. The panelists washed their palates between samples with water. The samples were served at room temperature (25±1°C) and analyses were performed under normal light conditions on a 5-point hedonic scale (from dislike extremely=1 tolike extremely = 5).

Statistical Analysis

This study was done in completely randomized factorial design and all experiments were performed in triplicate, and results were subjected to analysis of variance (ANOVA). ANOVA was performed according to SAS software. Duncan's multiple range tests was used to determin significant differences between means; P values <0.05 were considered statistically significant. Microsoft Excel 2013 was used to draw diagrams.

RESULTS AND DISCUSSION

Chemical Analyses of Pattypan Squash Extract

Total phenolic compounds

The TPC was increased by increasing concentration of PSE, which this was resulted in increasing the antioxidant activity. As is shown in Figure 1, a significant difference (P<0.01) between TPC of different concentrations of PSE was observed (Figure 1). The highest (24.28 mg/L) and the lowest (7.51 mg/L) TPC were measured for FE of pattypan squash at concentration of 800 ppm and 100 ppm, respectively. The comparison of TPC of FE and FPE of pattypan squash showed that the FPE had significantly higher TPC compared to the other extracts (Figure 1). The increase TPC and antioxidant activity by increasing extract concentration could be attributed to increasing the number of active compounds to react with free radicals (Tavakoli et al., 2013).

Free radical scavenging activity

The free radical scavenging activity was significantly (P<0.05) increased by increasing concentrations of FE and FSE of pattypan squash. The highest and the lowest free radical scavenging activity were measured for FE of pattypan squash and FSE of pattypan squash, respectively. The free radical scavenging activity of FE of pattypan squash at concentration of 800 ppm was significantly (P<0.05) higher than butylhydroxytolueen (BHT) synthetic antioxidant (200 ppm), however, the free radical scavenging activity of other concentrations of extract was lower. As well as, FE of pattypan squash at concentration of 800 ppm had significantly more free radical scavenging activity than FSE of pattypan squash (800 ppm).

The higher free radical scavenging activity of extracts can be attributed to their high phenolic and flavonoid contents (Tavakoli et al., 2013). This results are in agreement with observations of Sharififar et al. (2009) and Shukla et al. (2009) for Teucrium polium L. and ethanolic leaf extract of Stevia rebaudiana Bert., respectively. The researchers reported that free radical scavenging activity of extracts was increased by increasing concentration.

Physicochemical Analyses of Dried Pattypan Squash

Water loss (WL)

As is shown in Fig., a significant (P<0.05) difference between WL of the samples treated with different osmotic solutions and different dehydration times. The highest and the lowest WL values were measured for the sample treated

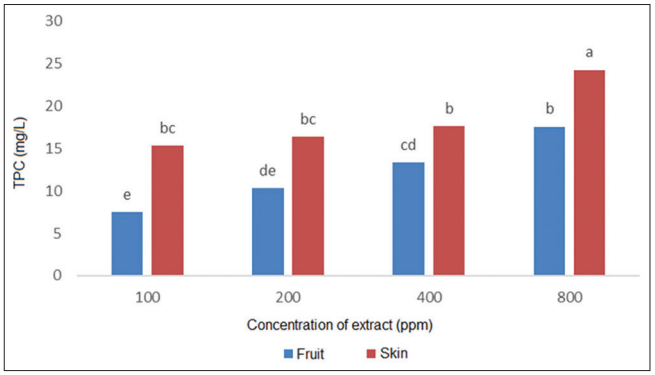

Figure 1: Effect of different concentrations of fruit extract (FE) and fruit skin extract (FE) of pattypan squash on TPC

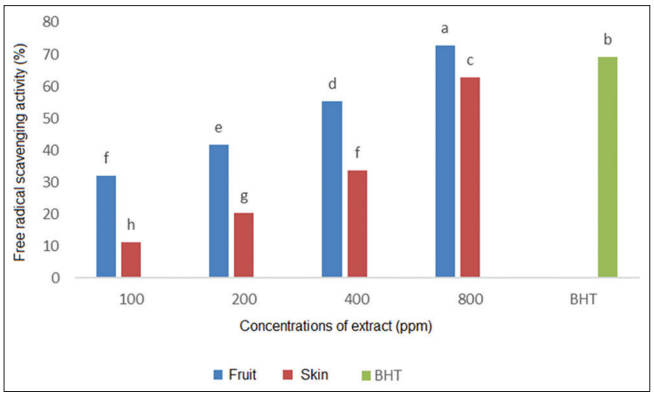

Figure 2: Effect of different concentrations of fruit extract (FE) and fruit skin extract (FE) of pattypan squash on free radical scavenging activity

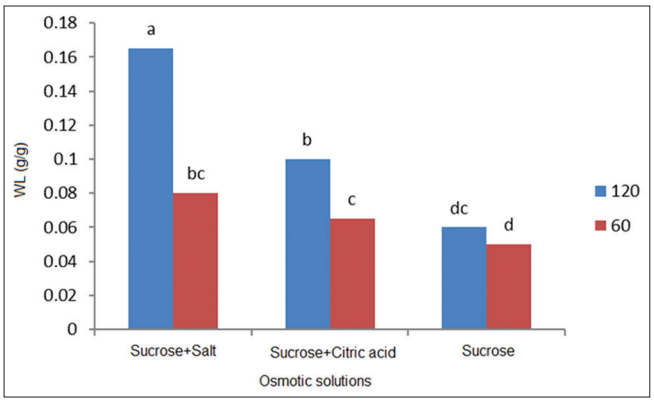

Figure 3: Effect of Osmotic solution and dehydration time on WL

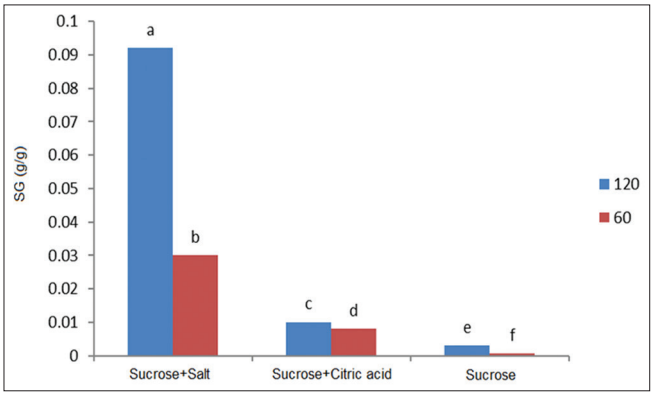

Figure 4: Effect of Osmotic solution and dehydration time on SG

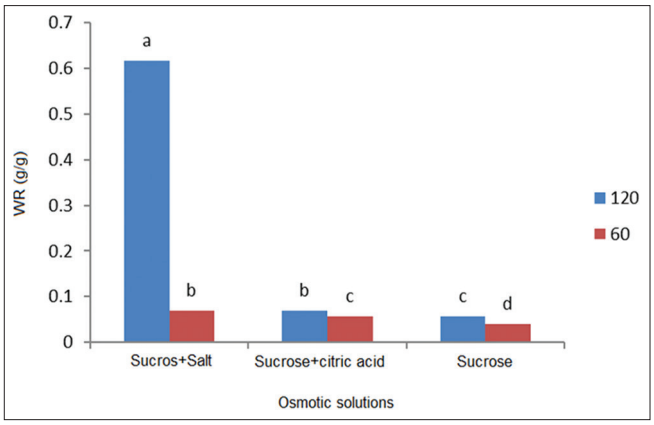

Figure 5: Effect of Osmotic solution and dehydration time on WR

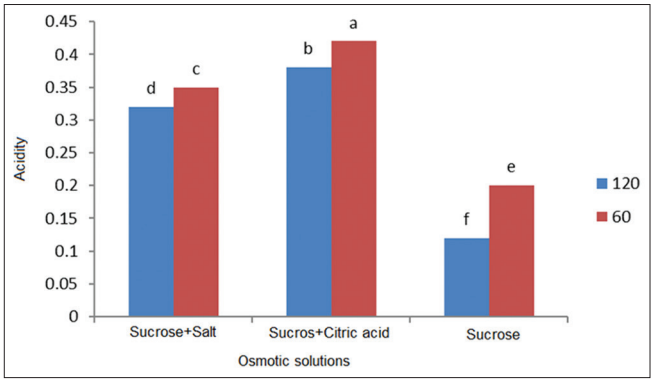

Figure 6: Effect of Osmotic solution and dehydration time on acidity

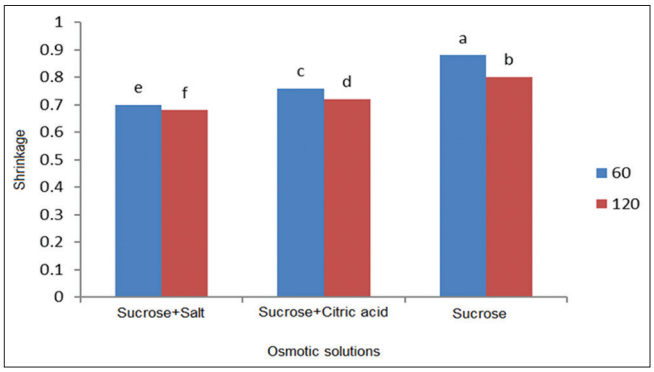

Figure 7: Effect of Osmotic solution and dehydration time on shrinkage

with sucrose+salt solution for 120 min and the sample treated with sucrose solution for 60 min, respectively. Because there is salt in sucrose+salt solution, this osmotic solution provides high osmotic pressure and thus much WL. In comparing with sugars, salt provides higher osmotic pressure, which this is due to each molecule of salt solution is decomposed to two ions. It is believed that the solutes with low molecular weight increase WL value due to high penetration rate. As well as, WL value is increased by increasing time of osmotic dehydration due to increasing osmotic driving force (Sabetghadam and Tavakolipour, 2015). Azarpazhooh and Ramaswamy (2009), Fernandez et al. (2009), and Cao et al. (2006) observed similar results for apple, pineapple, and kiwifruit, respectively. Chang et al. (2003) studied effects of salt addition in sugar based osmotic dehydration on mass transfer and browning reaction of green pumpkin. Their result revealed that dehydration rate was increased by increasing temperature and concentration of osmotic solution (Chang et al., 2003).

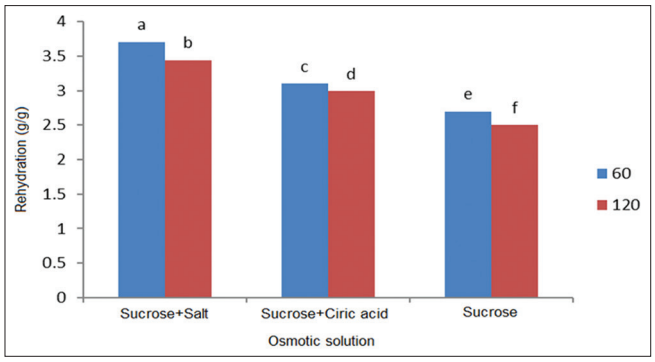

Figure 8: Effect of Osmotic solution and dehydration time on rehydration

Solid gain (SG)

Osmotic solution and dehydration time had significant ($P<0.05$) effects on the SG of dried samples. The highest and the lowest SG values were measured for the sample treated with sucrose+salt solution for 120 min and the sample treated with sucrose solution for 60 min, respectively. In sucrose osmotic solution, sucrose is placed in under surface of the tissue as a thin layer and acts as a barrier to mass transfer. However, in sucrose+salt osmotic solution, salt inhibits the formation of dense layer of sugar on the surface of the sample and leads to absorb water and soluble solids. This activity of salt is attributed to its low molecular weight (Sabetghadam and Tavakolipour, 2015). Since citric acid increases osmotic process in sucrose+citric acid osmotic solution and reduces bindings of water molecules to food components, the SG value of samples was increased. Krokida et al. (2000) studied effect of pretreatment on color of dehydrated products, and reported that SG value of potato dehydrated with osmotic solution was increased.

Weight reduction (WR)

Osmotic solution and dehydration time had significant ($P<0.05$) effects on the WR of dried samples. The highest and the lowest WR values were measured for the sample treated with sucrose+salt solution for 120 min and the sample treated with sucrose solution for 60 min, respectively. As mentioned in above, salt and citric acid increase osmotic dehydration rate, and thus lead to increase weight loss (Sabetghadam and Tavakolipour, 2015).

Acidity

Among the dehydrated samples, the sample treated with sucrose+citric acid solution for 60 min and the sample treated with sucrose solution for 120 min had the highest and the lowest acidity, respectively. In osmotic dehydration, juice is removed from fruit and replaced with low molecular weight dissolved solids such as organic acids, saccharides, vitamins, and mineral salts, which increases the acidity. Krokida et al. (2000) observed similar result in osmotic dehydration pretreatment of potato.

Shrinkage

The sample treated with sucrose solution for 60 min and the sample treated with sucrose+salt solution for 120 min had the highest and the lowest shrinkage, respectively. In sucrose+salt and sucrose+citric acid osmotic solutions, along with increase in winemaking, the SG is increased and thus reduces shrinkage. This fact is due to increasing tissue resistance because of dissolved solids penetration. As well as, the shrinkage was decreased by increasing osmotic dehydration time. It is believed that shrinkage of air-hot dried fruits is decreased by pretreatment with osmotic dehydration (Sabetghadam and Tavakolipour, 2015). Nieto et al (2014) reported that shrinkage of dried apple was decreased by increasing time of osmotic dehydration.

Rehydration

The highest rehydration value was measured for the sample treated with sucrose+salt solution for 60 min, which had significantly difference with other samples. This is probably due to solid gain in the osmotic dehydration that affects on permeability of cells, and therefore decreases the rehydration rate (Sabetghadam and Tavakolipour, 2015). Results of Rastogi et al. (2004) revealed that osmotic dehydration process had a negative impact on rehydration, which this is due to quick saturation of the lower layer surface texture of the food with sugar and less rehydration the sugar layer compared to natural texture of food. As well as, rehydration rate of the samples was decreased by increasing time of osmotic dehydration.

Sensory Evaluation

In this section, four sensorial properties of dried pattypan squash including flavor, color, texture, and overall acceptability were studied. The type of osmotic solution and time of osmotic dehydration had significant effect on the studied sensorial properties (Table 1). The highest desirability for flavor and texture were observed for the samples treated with sucrose+citric acid for 120 min. Since osmotic process is performed away from oxygen and heat, caused better maintenance of efficient agent in the flavor of product, and lead to increase the desirability (Lenart et al., 1989). The samples treated with sucrose+citric acid for 60 min had the highest desirability for color and overall acceptability. There is no contact with oxygen and presence organic acids (citric acid) can reduce pH of the solution, thereby reducing the enzymatic activity of phenolase, browning, and color change.

CONCLUSIONS

TPC and free radical scavenging activity of pattypan squash extract were increased by increasing concentration of extract. The sample dehydrated with sucrose+salt solution

Table 1: Sensorial evaluation of dried pattypan squash

Treatment	Dehydration time (min)	Flavor	Color	Texture	Overall acceptability
Sucrose+Citric acid	120	4.3a	4.5b	4.1a	4.0b
	60	4.2a	4.8a	4.1a	4.3a
Sucrose+Salt	120	2.8d	4.0c	3.7b	3.3d
	60	3.3c	4.5b	3.65b	3.7c
Sucrose	120	3.8b	3.2e	3.4c	2.9e
	60	3.4c	3.7d	3.4c	3.3d
Control	-	2.4e	2.8f	2.9d	2.6f

had the highest WL and WR. Treatment with sucrose+salt solution can be select as an osmotic dehydration pretreatment for drying pattypan squash, because of short dehydration time and low shrinkage and desirable sensorial properties of dried product.

REFERENCES

1. Azarpazhooh, E., &Ramaswamy, H. S. (2009). Microwave-osmotic dehydration of apples under continuous flow medium spray conditions: Comparison with other methods. Drying Technology, 28(1), 49-56.
2. Barbanti, D., Mastrocola, D., Severine, C. (1994). Drying of plums. A comparison among twelve cultivars. Sci des Alimen, 14, 61-73.
3. Burits, M., &Bucar, F. (2000). Antioxidant activity of Nigella sativa essential oil. Phytotherapy Research, 14(5), 323-328.
4. Cao, H., Zhang, M., Mujumdar, A. S., Du, W. H., & Sun, J. C. (2006). Optimization of osmotic dehydration of kiwifruit. Drying Technology, 24(1), 89-94.
5. Chang, M. J., Han, M. R., & Kim, M. H. (2003). Effects of salt addition in sugar based osmotic dehydration on mass transfer and browning reaction of green pumpkin. Agricultural Chemistry and Biotechnology, 46(3), 92-96.
6. Fernandes, F. A., Gallão, M. I., & Rodrigues, S. (2009). Effect of osmosis and ultrasound on pineapple cell tissue structure during dehydration. Journal of Food Engineering, 90(2), 186-190.
7. Kader, A. A., & Rolle, R. S. (2004). The role of post-harvest management in assuring the quality and safety of horticultural produce (Vol. 152). Food & Agriculture Organization.
8. Krokida, M. K., Kiranoudis, C. T., Maroulis, Z. B., &Marinos-Kouris, D. (2000). Effect of pretreatment on color of dehydrated products. Drying Technology,18(6), 1239-1250.
9. Kukić, J., Popović, V., Petrović, S., Mucaji, P., Ćirić, A., Stojković, D., &Soković, M. (2008). Antioxidant and antimicrobial activity of Cynaracardunculus extracts. Food Chemistry, 107(2), 861-868.
10. Kurniawati, P.T., Soetjipto, H. &Limantara, L. (2007). Antioxidant and antibacterial activities of Bixin pigment from Annatto (Bixaorellana L.) seeds. Indo. J. Chem., 7 (1), 88 – 92.
11. Lenart, A. and Grodecka, E., (1989). Influence of the kind of osmotic substance on the kinetics of convection drying of apples and carrots. Journal of Food Technology, 18, 27-35.
12. Nieto, A. B., Salvatori, D. M., Castro, M. A., &Alzamora, S. M. (2004). Structural changes in apple tissue during glucose and sucrose osmotic dehydration: shrinkage, porosity, density and microscopic features. Journal of Food Engineering, 61(2), 269-278.
13. Piasecka-Jóźwiak, K., Rozmierska, J., Chablowska, B., Stecka, K. M., Skapska, S., Kliszcz, M., &Szkudzinska–Rzeszowiak, E. (2013). Starter cultures for lactic acid fermentation of sweet pepper, pattypan squash and tomatoes. Pol. J. Food Nutr. Sci, 63, 95-102.
14. Raoult-Wack AL, Lenart A, Guilbert S. Recent advances during dewatering through immersion in concentrated solution. In A. S. Majumdar (Ed.), Drying of solids. New York: International Science Publisher 1992; pp: 21–51.
15. Rastogi, N. K., &Raghavarao, K. S. M. S. (2004). Mass transfer during osmotic dehydration of pineapple: considering Fickian diffusion in cubical configuration. LWT-Food Science and Technology, 37(1), 43-47.
16. Rostogi NK, Raghavarao KSMS. Mass transfer during osmotic dehydration of pineapple: consideringFickian diffusion in cubical configuration. Food Sci Technol 2004; 37: 43-47.
17. Sabetghadam, M., &Tavakolipour, H. (2015). Osmo-coating and ultrasonic dehydration as pre-treatment for hot air-drying of flavored apple. Engineering in Agriculture, Environment and Food, 8(4), 318-327.
18. Salminen, A., Lehtonen, M., Suuronen, T., Kaarniranta, K., Huuskonen, J., 2008. Terpenoids: natural inhibitors of NF-κB signaling with anti-inflammatory and anticancer potential.Cell Mol. Life Sci.65, 2979-2999.
19. Saurel R, Raoult-Wack AL, Rios G, Guilbert S. Mass transfer phenomena during osmotic dehydration of apple. I: Fresh plant tissue. Int J Food Sci Tech 1994; 29: 531-542.
20. Seiiedlou, S., Ghasemzadeh, H. R., Hamdami, N., Talati, F., &Moghaddam, M. (2010). Convective drying of apple: mathematical modeling and determination of some quality parameters. International journal of agriculture and biology, 12(2), 171-178.
21. Sharififar F, Dehghn-Nudeh G and Mirtajaldini M, (2009). Major flavonoids with antioxidant activity from Teucrium polium L. Food Chemistry 112: 885–888.
22. Shukla Sh, Mehta A, Bajpai VK, Shukla S. (2009). In vitro antioxidant activity and total phenolic content of ethanolic leaf extract of Stevia rebaudiana Bert. Food ChemToxicol; 47: 2338-43.
23. Tavakoli, J., Khodaparast, M.H.H., Aminiarim, M., Kenari, R.E., & Sharif, A. (2013). Introducing Pistaciakhinjuk (Kolkhoung) fruit hull oil as a vegetable oil with special chemical chomposition and unique oxidative stability. Chemistry of Natural Compounds, 49(5), 803- 810.

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