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Research Article

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The Effect of Osmotic and Ultrasound Pre-Treatment on Some Physicochemical Features of Avocado

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ABSTRACT

Today, drying is one of the important processes in food industry to increase durability of fruits and vegetables. Using osmotic and ultrasound processes before dehydration with hot air maintains nutritious materials in product and the need to thermal energy to eliminate the water of product is reduced. In this test, avocado was washed and peeled before osmotic dehydration and soya protein with level 5% was used) and Aloe Vera syrup was used as osmotic medium. Concentration of Aloe Vera was 35%, 55%. The slices of fruits were under ultrasound process for 30min (25kHz) and 180min (without ultrasound) and ambient environment and for additional drying, it was performed in hot air dryer at constant temperature 70℃. The results showed that by ultrasound, Shrinkage was reduced considerably and PH and rehydration were increased. Sensory evaluation regarding color, aroma, flavor, texture and total acceptance between coating samples and non-coating samples showed that non-coating samples had high acceptability compared to coating and control samples.
Keywords: *Avocado, Osmotic, Chemical features, Ultrasound*

INTRODUCTION

Avocado belongs to Lauracea family (1) and its scientific name is Persea Americana (2). Other common names as applied are alligator pear, Avocado (3). The origin of this tree is Mexico (4). Today, it is cultivated widely in arid and semi-arid areas. It has pear form fruits with circular core (5). Due to high fat, Avocado is high energy source and it is of great importance from nutritional aspects and it is a simple food or it is used as an important part in formulation of pharmacological and

cosmetic products (6). The flesh of avocado has 15-30 oil based on the type of variety and ecology of the region. In addition to fat, avocado is high-energetic food for diabetics (7). It is rich source of vitamins and proteins. It has high values of mineral namely potassium. Also, it has high fiber among other fruits including 75% non-solved fiber and 25% dissolved fiber (8). In developing countries about 5 to 15% of products are wasted. Drying products reduces the waste. Drying food namely fruits and vegetables is used to increase durability of product and it is also used as one of the important processes in food industry. One of the benefits of drying compared to other methods as freezing, canning and ray is maintenance of product under natural conditions, reduction of weight and volume of product and reduction of packing, warehousing costs, distribution of product and creating variety in manufacturing products. Hot air is a conventional method for drying food. Although it has adverse effects as change of color, stiffness of texture and reduction of quality on final product (9). To improve quality of products, some methods as osmosis, blanching before drying are used by researchers and their effects on qualitative properties of dried products are investigated (10). According to the researchers, osmotic pre-treatment for its easy and controllable method is a good pre-process for drying fruits (11). Osmotic dehydration is a process to eliminate a part of water of plant and animal products by submerging it in hypertonic solution and required driving force for transfer of water from food texture to osmotic solution is the difference between osmotic pressure of hypertonic solution and food texture and can be used as an independent stage or in combination with other processes as drying by air, freezing, frying, microwave, canning and etc. (12). Due to the application of osmotic solution (process waste) as the natural source of color, flavor and antioxidants, this process is economical and it also can control mass transfer coating during the process and reduce absorption of dissolved sold materials. Generally, coating materials before osmotic dehydration process without negative effect on water exit avoids the influence of dissolved sold materials to food texture. Cellular walls can be remained as complete and their thickness is similar to the thickness of new sample. Dehydration process by osmotic method leads to reduction of Shrinkage of final product compared to the samples as dried directly under hot air (10). Using coating besides control of osmotic process reduces food value and maintains organoleptic features as well (13). Also, in this study, ultrasound pre-treatment is used. Using ultra-sound waves increases humidity influence coefficient and reduces drying process. Due to cavitation, ultrasound waves create rapid expansion and contractions in matter as similar to compression and releasing of a sponge and water can exit solid matrix and creates micro channels for easy mass transfer during drying by hot air (14). Ultrasound drying is of great commercial importance. In this method, food is less damaged and is dried with low humidity percent (15). In this study, we investigated the combinational pre-treatment of coating and ultrasound osmotic dehydration process in drying process of avocado slices by hot air. The present study aimed to provide dried product of Avocado with good qualitative features.

Materials and Methods

Isolate of soya protecin with Amisoy was purchased from Netherland Elmeray Company. Aloe Vera: It was purchased from Kimya Khorasan.

2.1.Preparation

This fruit (Avocado)was provided from local market from Tehran of one variety. To reduce respiratory and biological activities to testing time in refrigerator, it was kept at temperature 4 °C. At the beginning of test, Avocado was washed and peeled, then by nicer dicer made in Germany was divided into circular slices with thickness 10mm. Avocado slices and their thickness were controlled with caliper with precision 0.02 mm.

2.2.Coating

To coat product before osmotic dehydration, Whey soya protein with level 5% was used. For coating process, avocado slices were submerged for 60s in coating 0.05. After coating of Whey, the specimen was put for 2min on filter paper to eliminate extra gel. Finally to fix coating, the specimen was put in hot air oven for 15min at temperature 70 °C (16).

2.3.Osmotic and ultrasound dehydration

In this study, Aloe Vera syrup was used as osmotic medium. Aloe Vera concentration was selected 35%, 55%. The dehydration process temperature during the process and in all treatments was constant and equal to ambient temperature (25 °C). The ratio of Avocado to osmotic medium was 1 to 4 (17). The tests were performed by applying dynamic conditions (agitation of osmotic solution) during once per hour (18). After coating and coating fixation, slices were under ultrasound (25 kHz) for 30min and 180 min osmotic (without ultrasound). After dehydration process, avocado slices were taken out of osmotic medium and they were washed with deionized distilled water and were put on filter paper (Wattman) to absorb water and for additional drying, they were put in hot air dryer equipped with air fan at fixed temperature 70 °C (19).

2.4.Qualitative test

2.4.1.PH

Also, PH was measured by digital pH meter (3510 model, Jenway company) (14).

2.4.2.Shrinkage

To measure Shrinkage, the specimens were dried at required temperature and then Shrinkage was determined by the following equation (20).

$$\%SKG = \frac{V_\circ - V}{V_\circ}$$

In this equation, Vo is fresh avocado slice (cm3) and V is volume of avocado slice and after drying (cm3). The samples volume was computed by toluene displacement method.

2.4.3.Rehydration

The specimen rehydration was computed via calculation of increase of weight of sample after 3 hours of submerging in distilled water at ambient temperature compared to dried weight before submerging at ambient temperature (21).

2.4.4.Sensory evaluation

Sensory evaluation test was performed by a group of sensory analyzer composed of 5 food industry experts. All evaluations were performed by product-oriented sensory test (scoring method of severity of a property) with 5-point hedonic scoring. Some questionnaires were provide and 5 questions were asked of each person and 5 choices were used for the responses. The questions were color, flavor, taste, aroma, touch and total acceptance. It is worth to mention that age group of analyzers as men and women were 25-50 years old (22).

3.Data analysis method

This test was factorial test in fully randomized design with 3 replications. The comparison of mean of Tukey HSD was performed by Dunckan test at 5% level and to perform variance analysis, SAS software, version 9.1 was used and chart was ploted with Excel 2007.

Results and Discussion

4.1.PH

Based on the effect of time and concentration type of dehydration medium during osmotic and ultrasound dehydration on PH of Avocado, the highest amount was observed in solution 35% and ultrasound for 30min (Chart 1). The results showed that the mutual effect of time and concentration of dehydration medium under ultrasound and osmotic medium was significant at level 5%. Sugar and acidic materials (ascetic acid) were absorbed from osmotic medium to fruit texture and increased acidity and reduced PH. By increasing drying time of specimen, 55% at temperature 70 °C, due to level hardening and increase of sugar in Avocado to organic acids (ascetic acid) increased acidity and reduced PH in specimen 55% compared to specimen 35% (23). Absorbed organic acids from osmotic solution can reduce PH of production and phenolase enzyme activity and browning is reduced (24, 16, 14). As drying time of specimen under dehydration with ultrasound was lowered due to cavitation compared to osmotic dehydration, the specimen were less exposed to hot air oven. Thus, less amount of sugar was remained in Avocado and were converted to organic acids in ultrasound and acidity was reduced in ultrasound and increased PH (23). Eshraghi et al., (25) evaluated the effect of ultrasound on drying Kiwi slices and stated that by increase of ultrasound time, humidity time 20% was reduced. Also, drying time was reduced and the specimen were dried at short time. Radmard Ghadiri (26) by various temperatures during dried plum showed that the increase of PH led into the increase of temperature and drying time.

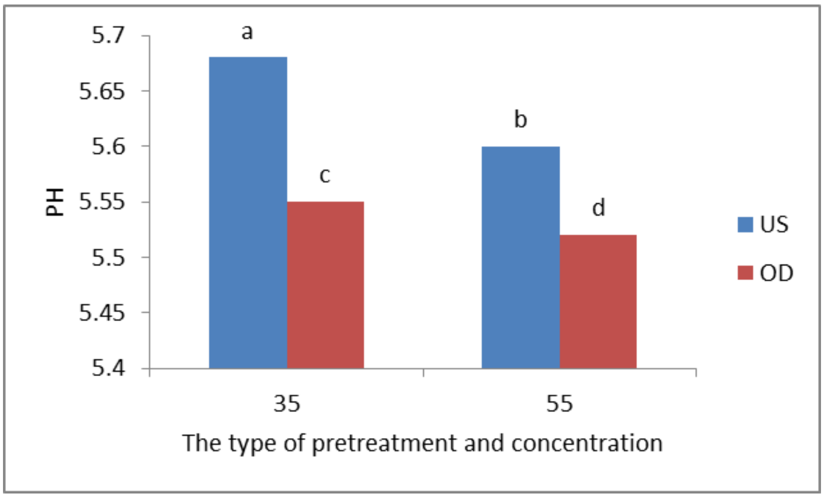


Figure 1. The effect of time and dehydration medium on PH of Avocado during dehydration process

Based on the effect of coating on PH in avocado, the highest PH value was observed in non-coating specimen with significant difference at level P<0.05(Chart 2).

As drying time of coated samples were less than non-coating samples, dehydration was higher in coated samples compared to non-coating samples and food coating increased osmotic dehydration efficiency (Jalayi et al.,). The increase of drying time in non-coating specimen caused that samples were exposed to hot air of oven at much time (Seraji et al.,). Thus, high amount of sugar in Avocado was converted to organic acids and acidity was reduced and PH was increased and this increased the sugar of sample to organic acids and increased acidity and reduced PH (27). Tavakolipour et al., during Rheum drying found that by increase of temperature, sugar in fruit was converted into organic acids and acidity was increased and PH was reduced.

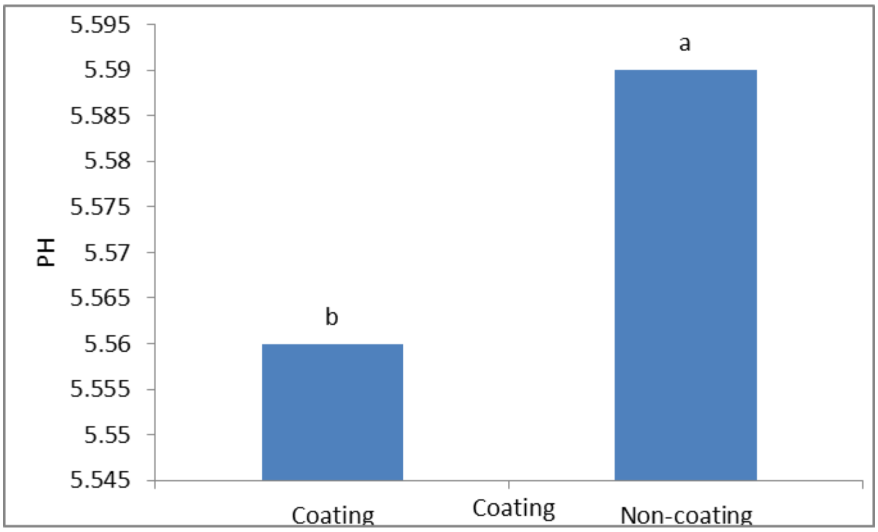


Figure 2. The effect of coating of osmotic dehydration medium on PH of avocado

4.2.Shrinkage

Based on the effect of medium type and using ultrasound pre-treatment on Shrinkage in Avocado, the lowest Shrinkage in ultrasound 30min in solution 55% was observed (Chart 3)

Under ultrasound pre-treatment, less Shrinkage is observed compared to osmotic specimen and in osmotic media, less Shrinkage was observed in solution 55% compared to 35% solution. By the increase of concentration, solid absorption was increased and Shrinkage was reduced. Due to long osmotic dehydration time (180min) and level hardening at high concentrations, less Shrinkage was observed at concentrations 55% of osmotic solutions compared to concentrations 35%. Shahidi et al., (27) evaluated the effect of osmotic and ultrasound pre-treatment on some properties of dried banana by hot air method and stated that by increase of concentration, solid absorption percent was increased and Shrinkage was reduced. High concentrations and long dehydration time created a hard crystal layer on surface. This state during drying created hardening and avoided Shrinkage.

Ultrasound pre-treatment and cavitation reduced connection of water molecules to food and the specimen was dried at short time and Shrinkage was reduced (26).

Jambrak et al., (28) evaluated the effect of ultrasound on mass transfer and rehydration in drying button mushrooms, Brussels cauliflower sprouts and the results showed that in pre-treatment samples with ultrasound, mass transfer was increased and hot air drying time was reduced and re-absorption of water was increased and Shrinkage and texture damage were less. Schossler et al., (29) showed that ultrasound pre-treatment reduced drying time due to the increase of effective diffusion of humidity. In addition, ultrasound reduced Shrinkage and increased volume ratio compared to control treatment.

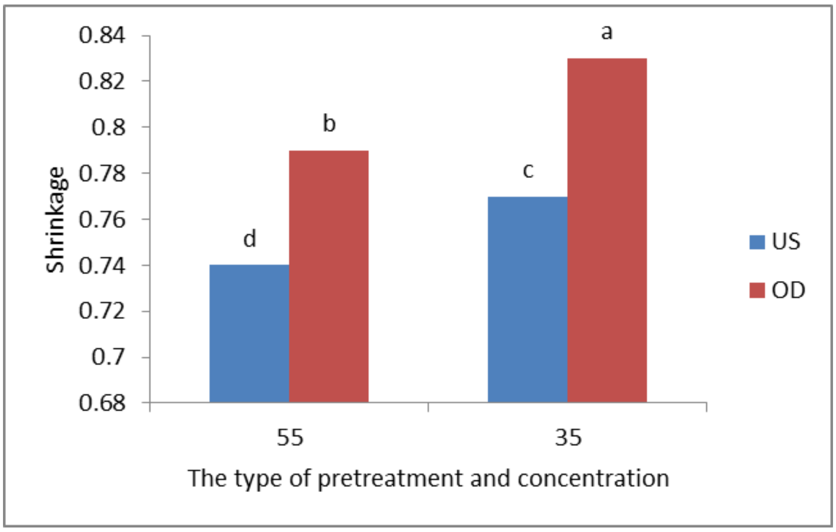


Figure 3. The effect of time and dehydration medium on Shrinkage of Avocado during dehydration process

Based on the effect of coating on Shrinkage in Avocado, the highest Shrinkage was observed in non-coating specimen with significant difference at level P<0.05 (Chart 4). By increase of drying time in non-coating specimen compared to coating samples, reduced connection of water molecules to food and sample was dried at short time and Shrinkage was reduced (26). Based on the effect of coating on Shrinkage in Avocado, the highest PH was observed in non-coating samples and lowest value in non-coating samples with significant difference at level P<0.05.

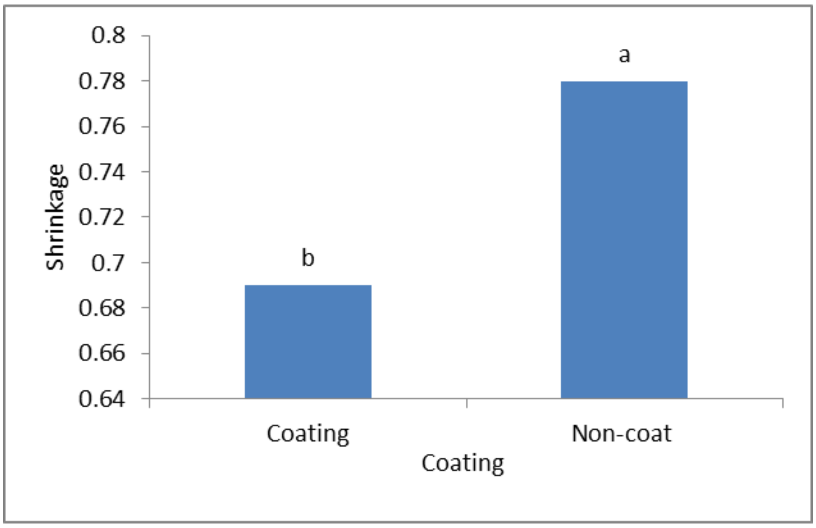


Figure 4. The effect of coating on Shrinkage of Avocado during osmotic dehydratio

4.3.Re-hydration

Based on the effect of time, type and concentration of dehydration medium during osmotic dehydration and ultrasound on re-hydration in Avocado, the highest rehydration wasobserved at ultrasound 30min in solution 35% with significant difference at level P<0.05. Less re-hydration was observed in osmotic state compared to ultrasound due to solid absorption in osmotic process and this was effective on cells permeability and re-hydration was reduced (27). The results of studies of Bakalis and Caradonoze (2005), Rastogi et al., (2004), Leoyiki (1998) and Fakhri Shahidi et al., (2011) showed that osmotic dehydration process had negative effect on re-hydration and the reason was rapid saturation of lower layer of food texture with sugar and less hydration of sugar layer compared to natural texture of food. The osmotic solution concentration was effective on re-hydration as by increase of osmotic solution concentration due to high solid absorption, rehydration of samples was reduced (27). Ultrasound waves increased re-hydration compared to osmotic (without ultrasound) due to microscopic channels of cavitation and sponge effect. Dried samples with ultrasound had porous texture compared to dried sample by osmotic solution (without ultrasound) and control sample and it absorbed water better (26). Eshraghi et al., (25) evaluated the effect of ultrasound on drying Kiwi slices and stated that the increase of ultrasound time increased rehydration of dried kiwi samples compared to control sample. As ultrasound waves can create sponge state in product, it can absorb water easily and it can achieve maximum water absorption. Jambrak et al., (2006) applied ultrasound waves for rapid drying of button mushrooms, Brussels sprouts and cauliflower. By the increase of ultrasound time, due to creating high microscopic channels, based on cavitation, the sample has highly porous texture compared to control sample and also it has good water absorption. The increase of re-hydration in control sample was less in ultrasound waves compared to dried sample (Chart 10). They are consistent with the results of Jambark et al., (2006). Ashraghi et al., (25) evaluated drying Kiwi slices with ultrasound and stated that by increase of ultrasound time, due to high microscopic channels, due to cavitation and sponge effect, the dried Kiwi sample had highly porous texture compared to control sample and it had good water absorption compared to control sample. Cavitation had considerable role in separation of water connected to food. The required time for drying was reduced and Shrinkage was reduced and re-hydration was also increased. The results of Jambark et al., (2006) and Blanko et al., (2006) and Dolavtuski (30) regarding drying time showed that increase of rehydration in control sample was higher than dried samples at osmotic state (without ultrasound). Based on the negative effect of osmotic process on rehydration and rapid saturation of lower layer of food texture with sugar and less dehydration of sugar layer compared to natural texture of food is justified (27).

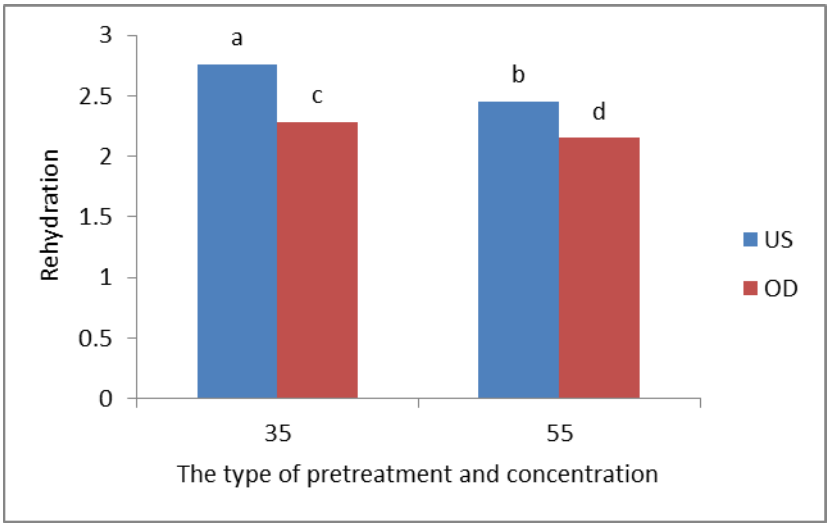
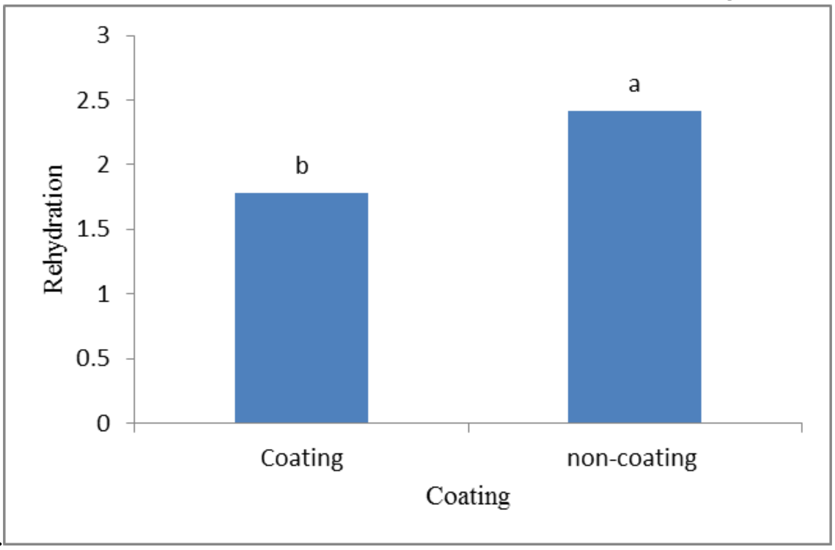


Figure 5. The effect of time and dehydration medium on rehydration of Avocado during dehydration process

The results of variance analysis of rehydration of Avocado during osmotic dehydration showed that the effect of coating at statistical level 5% was significant on Avocado rehydration property ($P<0.05$). Low rehydration in coating samples compared to non-coating due to solid absorption in osmotic process and this was effective on permeability of cells and rehydration was reduced by samples (27). The maximum increase of solid absorption in non-coating was observed. Absorption of dissolved solid in coating samples was less than non-coating samples. The results showed that materials coating before osmotic dehydration prevented the influence of solid materials of solution to food texture and had no negative effect on water exist



(6).

Figure 6. The effect of coating on rehydration of Avocado during osmotic dehydration process

4.4.Sensory properties of dried Avocado

To evaluate organoleptic properties of dried samples, 4 sensory properties including color, texture, flavor and tastes and total acceptance were evaluated (Table 1).The results of various researchers regarding the effect of osmotic pre-treatment on aromatic maintenance showed that due to osmotic process in environment without oxygen and heat increased the durability of aroma and flavor of product and also increased its fresh property (11). Using coating besides osmotic process control reduced loss of nutrients and organoleptic properties as coating avoided humidity loss. During fruit dryness, humidity is lost and chewing dry fruit is hard and coating makes the fruit soft and chewing can be easier. Also, aroma and flavor of fruit are kept and also the fruit can be kept for a long time. This coating creates shining coat on fruit and fruit stickiness is avoided. Coating dried parts avoids much aroma and flavor (31). In terms of chewing, the results show that osmotic samples had high rank compared to other products. This issue is regarding crystal structure compared to chewing of texture and this issue is considered well by analyzers. The higher the humidity, the lower the brittleness . Regarding the color, the color of treated samples by osmotic dehydration method had high acceptance compared to ultrasound dehydration. In osmotic

dehydration, due to the increase of dryness of sample and hardening and increase of converting sugar in Avocado to organic acids (Ascetic acid) reduced phenolase enzyme activity and browning (24, 16, 32).

Table 1: The sensory evaluation results of dried Avocado

Total acceptance	Texture	flavor and taste color	coating	osmotic process	concentration of osmotic solution	
3/7^{e}	4/2^{b}	3/7^{d}	3/1^{f}	-	Osmotic	55
3/5^{g}	3^{f}	3/5^{e}	3/4^{e}	-	Ultrasound	55
4/2^{c}	4/6^{a}	4/6^{a}	3/7^{d}	+	Osmotic	55
4/7^{a}	4^{c}	4/2^{b}	4/5^{b}	+	Ultrasound	55
3/9^{d}	3/2^{e}	3/1^{f}	3/38^{e}	-	Osmotic	35
3/1^{h}	3/2^{e}	2/7^{g}	3/7^{d}	-	Ultrasound	35
4/4^{b}	4/6^{a}	4/2^{b}	4/2^{c}	+	Osmotic	35
3/9^{d}	3/7^{d}	4^{c}	4/9^{a}	+	Ultrasound	35
2/9^{h}	2/27^{g}	2/3^{h}	2/7^{g}			Control

Conclusion

By various pre-treatments, we can reduce disadvantages of drying process and turn it into a technology with high value added with better physicochemical properties compared to conventional samples. In this study, after pre-treatment of coating, osmotic and ultrasound, the samples were dried in hot air oven and Shrinkage, rehydration and PH and sensory evaluation were evaluated. The results showed that ultrasound compared to osmotic dehydration caused that using acidity ultrasound reduced Shrinkage in fruit significantly and increased PH and rehydration. Sensory evaluation of color, aroma, flavor, texture and total acceptance between coating and non-coating samples showed that non-coating samples had high acceptance compared to coating samples and control samples. Finally, we can say coating of Avocado samples with isolate of Soya protein and by ultrasound dehydration process based on reduction of drying time and creating high quality product could be a good pre-treatment to increase quality of avocados dried by conventional method.

References

1. Zargari, A., 1990. Herbal medicine. Tehran University publications. P. 346-349.

2. Bora, P. S., Narain, N., Rocha, R. V. M. & Paula. M. Q. (2001). Characterization ofthe oils from the pulp and seeds of avocado (cultivar: Fuerte) fruits. Grasas y Aceites, 171-174 Ding, H., Chin, Y. W., Douglas Kinghorn, A. & D' Ambrosia, S. M.17- (2007) Chemo preventive characterization of avocado fruit. Seminar in Cancer Biology, 17: 386-394.

3. Efendi, D. (2003). Trasformation andn cryopreservation of embryogenic avocadocultures. A Dissertation Presented to the Graduate of the University of Florida in Partial Fulfillment of the Requirement for the Degree of Doctor OF Philosophy, 4-6

4. Salazar, M. J., Hafidi, M. E. L., Pastelin, G., Rmirez-Ortega, M. C. & Sanchez-Mendoza, M. A. (2005). Effect of an avocado oil – rich diet over an angiotensin II- indused blood pressure response. Journal of Ethnopharamocolory, 98, 335-338

5. Salehi, Sormaghi, M., H., 2006. Herbal medicine. Nutrition world University publications. P. 51-52.

6. Ali, Kh.M.,(2002). Factors influencing the quality and shelflife of mango pulp dehydrated in a sheet form(mangodeen). M.Sc. Thesis. Faculty of Agriculture.University of Khartoum

7. Samson, J. A. (1986). Tropical Fruits. Second Edition. Longman. Landon, 253. Shahidi, F. (2005). Bailey's Industerial,Oil and Fats Products. Sixth Edition. John Wiely and Sons, Inc, 5, 388-389

8. Naveh, E., Werman, M. J., Sabo, E. & Neeman, I. (2002). Defatted avocado pulp26 Reduces body weight and total hepatic fat but increases plasma cholesterol in male rats fed diets with cholesterol. J.

9. Amiri, M., 2012. The evaluation of using osmotic dehydration as pre-treatment in drying pear by hot air and vacuum and optimization of drying conditions with response level method. K rokida,M.,Kiranoudis,C.,Maroulis,Z.,Marinos-Kouris,D.,(2000),Effectof pretreatment on color of dehydrated products , Drying Technology,18(6),pp.1239-125

10. K rokida,M.,Kiranoudis,C.,Maroulis,Z.,Marinos-Kouris,D.,(2000),Effectof pretreatment on color of dehydrated products , Drying Technology,18(6),pp.1239-125

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. Emam Jome, Z., Tahmasebi, M., Piruzifar, Kh. Asgari, Gh. 2008. The evaluation of the effect of osmotic pre-treatment on texture properties of dried tomato with air. Engineering of Biosystem in Iran journal. 133-139.

13. Mamoun, O.A. &.Inaam,A.I,(2011).Application of Gum Arabic for Coating of Dried Mango Slices.pakistan.journal of Nutrition 10(5):457-462

14. Iran national standard 4404. 1992. PH measuring method in fruits and vegetables.

15. Spiazzi, E and Mascheroni,R(1997).Mass transfer model for osmotic dehydration of fruits and vegetables. I. Development of the simulation model. J. Food Eng. 34:387-41

16. Hadad Khodaparast, M., Jalayi, F., F. Forghani, M. 2008. The evaluation of using pectin, Carboxine Cellulose and starch in drying –osmotic of apple and determining some of effective factors. The 18th national congress of food industry and sciences. P. 1, 7.

17. Emam-d jomeh, Z., (1998), Transferent deau et de solute lorsde La deshyration dun aliment model et de vi and par immersion dans des solutions a plusieurs constituantsso these de. Doctoral cleimont FD franc

18. Ponting, J. D., (1996), Osmotic dehydration of fruit, food tochnology, 125-12827-

19. Seiiedlou, S., Ghasemzadeh, H.R., Hamdami, N., alati, F.T., and Moghaddam, M.(2010). Convective drying of apple: mathematical modeling and determination of some quality parameters. International Journal of Agriculture and Biology, 12:171-178

20. Sioholm, I., & Gekas.V. (1995).Apple shrinkage upon during, Journal food engineering.25:123-130

21. Hammami, C., Rene, F. & Marin, M., (1999), Process quality optimization of the vacuum freeze- drying of apple slices by the response surface method.International Journal of Food Science and Technology. 34:145-160.

22. Watts, B. M. (1989). Basic Sensory Methods for food Evaluation. Translated by Ghazizadeh, M. and Razagi, A. Theran. Institute of Research Nutrtion and Food Science Publications. PP 95-114. (In Farsi)

23. Tavakolipour, H., Sharifi, A. 2008. Optimization of drying Rheum to provide Rheum powder. The 18th national congress of food industry and sciences.

24. Akbarian, M., Ghanbarzade, B., Dehghanian, J., Soti Khiabani, M. 2012. Optimization of osmotic solution and evaluation of osmotic dehydration effects on texture and color properties of fruit on active polysaccharide coating on texture and color properties. Journal of science and food industry researches. Vol. 9. No. 2. p. 165-174.

25. Eshraghi, A., Maghsudlou, Y., Kashaninejad, M., Beyraghi Tusi, Sh., Alami, M. 2011. The investigation of the effect of ultrasound treatment on drying Kiwi slices. Journal of food industry and sciences research in Iran. Vol. 7. No. 4, p. 173-179.

26. Radmard Ghadiri, Gh. Kalbasi Ashtari. A., 2011. The journal of food industry and sciences research of Iran. Vol. 7. NO. 4, p. 324-329.

27. Shahidi, F., Mohebi, M., Noshad, M., Ehtiati, A., Fathi, M., 2011. The evaluation of the effect of osmotic and ultrasound pre-treatment on some qualitative properties of dried banana by hot air method. Journal of sciences and food industry researches. Vol. 7, NO. 4, p. 26-277.

28. Jambrak, A. R., T. J. Mason, L. Paniwnyk, and V. Lelas.(2007). Accelerated drying of button mushrooms, Brussels sprouts and cauliflower by applying power ultrasound and its rehydration properties. Journal of Food Engineering. (81): 88-97.

29. Schossler, K., H. Jager, and D. Knorr. (2012). Effect of continuous and intermittent ultrasound on drying time and effective diffusivity during convective drying of apple and red bell pepper. Journal of Food Engineering. (108): 103-110.

30. Fabiano, A.N,Fernandes, and S. Rodrigues. (2007). Ultrasound as pre-treatment for drying of fruits: Dehydration of banana",Journal of Food Engineering. (82): 261-267.

31. National standard of Iran. NO. 373. First edition.

32. Soti Khiabani, M., Sahari, M., Emam Jome. z. 2003. Optimization of peach drying by Osmosis. Journal of agricultural sciences in Iran. NO. 34, 383-291

33. Maskuki, A., Mortezavi, A., Maskuki. A., 2007. The evaluation of the effect of ultrasound and alkaline on reduction of grape drying time. Journal of nutrition and food industry in Iran. Year 2. Vol. 5. p. 1-10.

34. Standard and industrial research institute in Iran. 1992. Fruit and vegetable products. Acidity determination.