International Journal of Agricultural Science and Research Volume 2, Number 2, Spring 2011(Serial #3)

A Comparative Study on Drying and Coating of Osmotic Treated Apple Rings

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Received: July, 24, 2011 *Accepted: October, 17, 2011*

ABSTRACT

In this study, the effect of edible coat (carboxy methyl cellulose) before osmotic dehydration and different drying methods on sensory and physical properties of dried apple (V. *Golden delicious*) rings was investigated. The coated and non-coated samples pretreated with 50% sucrose osmotic solution and dried in freeze drier (-40 to -50°C, 0.026-0.017 mbar, 24 hr), vacuum drier (70°C, 200 mbar, 8-10 hr), air dryer (60°C, 1.5 m/s, 2-3 hr). Sensory evolutions, Rehydration ratio (RR), color changes (ΔE), shear strength (SS), true density and shrinkage present of dried samples were determined. Effect of using edible coats before osmotic process was significant on the SS, RR and color changes. As the lowest shrinkage, color changes, RR, and highest SS were found in freeze dried apples. The air and vacuum dried samples had the highest RR and true density, respectively. The best sample in sensory evolutions was coated and freeze dried samples.

Keywords: Freeze drying; Vacuum drying; Air drying; Coating; Osmotic pretreatment; Physical properties.

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INTRODUCTION

One of the methods to increase shelf life is drying (Famurewa *et al.,* 2006). Dried fruits are beneficial to human health because they are a rich source of vitamins, minerals, anti-oxidants, and especially fiber (including soluble fibers) due to their concentration during processing (Konopacka *et al.*, 2009). The effect of convention drying is to change the structure, non-enzymatic browning, loss of vitamins and volatile flavor compounds (karel, 1980; Lewicki, 2004; Warczok, 2005). Convective drying of fruits is a widely exploited process to increase shelf-life, reduce packaging costs, to lower shipping weights and to maintain nutritional value. However, drying affects the quality of the final product due to extensive shrinkage and micro-structural changes in vegetable tissue (Gobbi, 2009).

Therefore, the best option would be to combine it with some pre-treatment preserving method, which will decrease the heat exposure time (Warczok, 2005). One of the non-thermal preserving methods is osmotic dehydration (OD). OD involves soaking foods such as fruit, vegetables in a hypertonic (osmotic) solution i.e. concentrated sugar, salt, alcohols or soluble starch solutions, which partially dehydrates the food (Mújica-Paz *et al*., 2003; Erle & Schubert, 2001). The differences in chemical potential between components in the solution and the material lead to mass transfer. This mass transfer involves water transfer from the material to the solutions, uptake of solutes from solution into dehydrated material and leach low molecular mass compounds, minerals, vitamins, colorants from the material to the osmotic medium(Sablani & Rahman, 2003; Mayor *et al*., 2006). It can improve food quality (reduce heat damage) when combined with air, freeze or vacuum drying (Pękosławska & Lenart, 2009). This process has received considerable attention as a pretreatment since it reduces energy consumption, inhibits micro organism's growth, retains the fruit natural color (without sulfide addition) and also helps to retain volatile aromas during the subsequent air-drying (Sueli & Fabiano, 2007).

Edible coatings are used as barriers to protect the plant tissue from adverse microbiological, chemical and physical changes (Lenart & Dobrowska, 2001). The coatings should be biodegradable, capable of modifying the product’s surrounding i.e. to act as a promoter of water removal (Ljubinko *et al*., 2008). The edible coatings are usually made of various polysaccharides, proteins or lipids. For their successful application in osmotic dehydration process, the properties of coating materials should fit several requirements: good mechanical properties, satisfactory sensory properties, easy and rapid film formation, high water diffusivity and prevention of excessive solute uptake by the tissue (Camirand, 1992).

The aim of the present work was to investigate the effect of coating and different drying on the sensory and physical properties of osmotic treated apples rings.

MATERIAL AND METHODS

Raw material

Apples (var. Golden delicious) of uniform quality were purchased at the local market in Karaj, Iran and stored at 1±1ºC and 80-90% relative humidity for 2 days, until they achieve an equal temperature. Then fresh apples were washed, peeled, cut into flat rings with 5 mm thickness, and then cored with circular mould. The initial content of the fresh apples varied from 84.1-84.7% (wet basis).

Coating treatment

The ring of apples immersed in CMC solution (0.5%) for 30 second and then put in calcium chloride solution (2%) for 2 minutes. Then they dried at 55-60°C for 5-10 minutes, because the coat has fixed on the samples.

Osmotic treatment

Osmotic treatment was carried out at 30°C using sucrose hypertonic solution (50%) about 180 minute. The fruit to solution mass ratio was 1:4.

Drying

After osmotic treatment, drying of samples performed in a pilot plant tray-dryer at an air temperature of 60°C and air velocity of 1.5 m/s with direction of air flow through the product for 2-3 hours. The freezing technique to submit was with liquid nitrogen. Freeze-drying tests were performed with vacuum chamber total pressure and temperature equal to 0.017-0.026 mbar and -40°C to-50°C, respectively. Average freeze-drying time was approximately 24 hr. Vacuum drying was performed in 70°C and 200 mbar for 8-10 hours. The drier type Ehret VTs 70 was used for vacuum-drying, GPERGN model was used for freeze-drying and Armfield Itd. 13481 was used for air-drying. The final moisture content of dried samples was 12±2 percent.

Analytical Methods

Rehydration Ratio (RR): The samples were rehydrated by immersing them in a water bath at ambient temperature (25°C). The approximate ratio of dried fruit and water volume was kept 1:10. The rehydrated fruits were spread on absorbent paper for the removal of free water on the surface of fruits. The maximum time of immersion of fruit sample was 6 hours (Fathabadi, 2008). Then the RR is calculated by bellow equation:

$$Rehydration\ Ratio = \frac{Weight\ of\ rehydrated\ apples\ (g)}{Weight\ of\ dehydrated\ apples\ (g)} \qquad \text{(eq. 1)}$$

Shrinkage: It was calculated as the percentage change from the initial apparent volume. The shrinkage is calculated as:

$$\%\ shrinkage = \left[1 - \left(\frac{V_t}{V_0}\right)\right] \times 100 \qquad \text{(eq. 2)}$$

Where $V_{\circ}$ and V_t denote the initial and dried volume of the same apple slice, respectively (Singh *et al.*, 2007).

True density: It was determined by displacement method with toluene before and after drying (Mohsenin, 1986).

Color measurement: It was conducted using a colorimeter HUNTERLAB-D25-9000 to obtain CIElab values ,L* (illuminance), a* (red-green index) and b* (yellow-blue index).The subscripts 0 denote the color parameters of fresh apples. The higher ΔE represents greater color change from the fresh apple (Seiielou *et al.,* 2010).

$$\Delta E = \sqrt{(L^* - L_0^*)^2 + (a^* - a_0^*)^2 + (b^* - b_0^*)^2} \qquad \text{(eq. 3)}$$

Shear strength on Texture: It was measured using a Texture Analyzer (HOUNSFIELD-H5K5) with 6.4 mm penetration probe (Fathabadi, 2008).

Sensory evaluation: For sensory evaluations color, chew ability, flavor, appearance, overall acceptability were investigated by 9 trained panelists, which ranges from 1 (dislike extremely) to 5 (like extremely). The sensory evaluation was conducted using the hedonic test (Payan, 1997).

Statistical Analysis

The experiment was conducted according to a completely randomized design. Data were evaluated by analysis of variance (ANOVA) and Duncan test, using SPSS-16 software version 16.0.

RESULTS AND DISCUSSION

The results of analysis of variance for dried apples were shown in Table 1.

Table 1: Analysis of variance for dried apple

Factors	Df	Shear strength	Shrinkage	True Density	Rehydration ratio	ΔE
Coat (C)	1	**	**	ns	**	**
Drying (D)	2	**	**	**	**	**
C*D	2	**	ns	ns	Ns	**
Errors	12					
R^2		0.999	.996	.989	.997	.996

**: p<0.01, *: p<0.05, ns: no significant

Rehydration ratio: Drying products have decreased in the water absorption and maintenance capacity in the plant tissue. During the rehydration, there follow a loss in soluble constituents of the dry matters of rehydrated materials that depend mainly on the chemical composition and the structure of tissues (Bogdan, 2008). As shown in (Figure 1), the rehydration ratio is highest for air dried samples and lowest for freeze dried samples due to porosity formation during sublimation of ice from the slice matrix (Phongsomboon & Intipunya, 2009) and changing the water holding capacity during long time of rehydration. Similar result was reported for carrot drying after long time of rehydration (Bogdan, 2008).

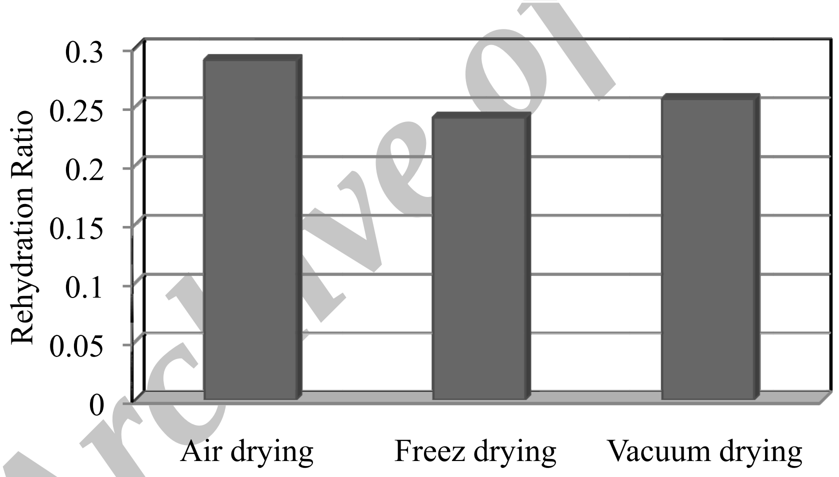

Fig.1: Effect of drying method on RR

As shown in (Figure 2) using of edible coats before osmotic pretreatment cause that the rehydration ratio of coated samples has been lower than non coated samples due to production sticky layer on the surface of coated samples (Tavakolipor *et al.,* 2008).

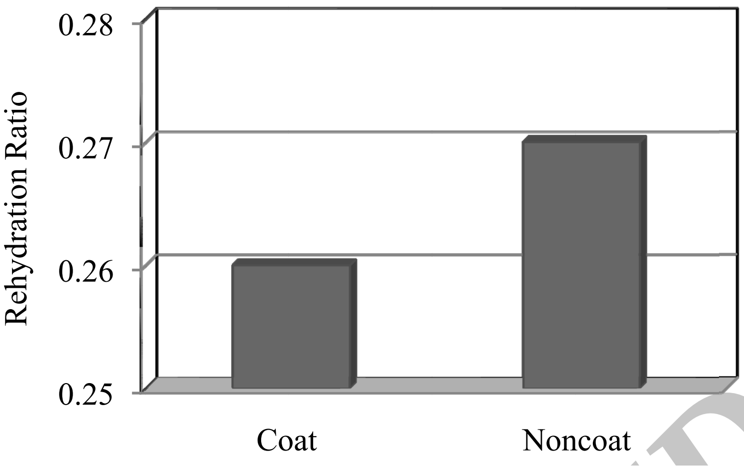

Fig. 2: Effect of drying method on RR

Shrinkage: The drying of a product usually results in smaller size than the original wet form. The shrinkage of samples has shown in fig. 3. The shrinkage in volume is dependent on the density. Most of the shrinkage occurs in the early drying stage, where 40 to 50% shrinkage may occur (Okos *et al.,* 1992). Freeze dried sample had been the lowest shrinkage present. According to Mauro *et al.* (2004), vacuum dried sample presented higher density and higher volume reduction than air dried sample, reflecting the collapsing of the solid matrix and remaining wet for longer time. In other research, shrinkage of freeze dried apple was lower than air dried apple (Morira *et al.,* 2000).

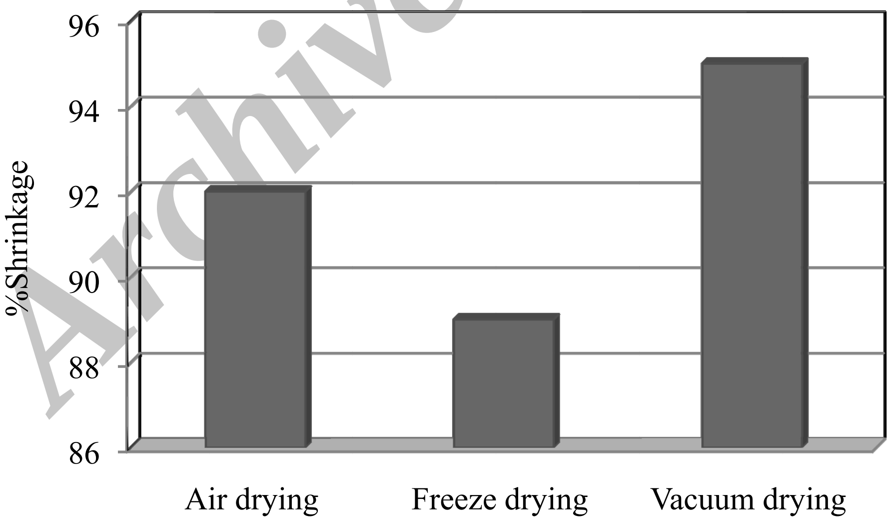

Fig.3: Effect of drying method on shrinkage present

The effect of coating was significant on the shrinkage of samples. As shown (figure 4) coated apples presented lower shrinkage than non-coated samples. In a research had shown that the solute uptake was in the cells of the non-coated samples larger than coated samples. In the non-coated apples, collapse of external cells due to large solute uptake was observed. This agrees with the lowest diffusivity of water obtained in the non-coated apples at final drying period (Khin *et al.,* 2007).

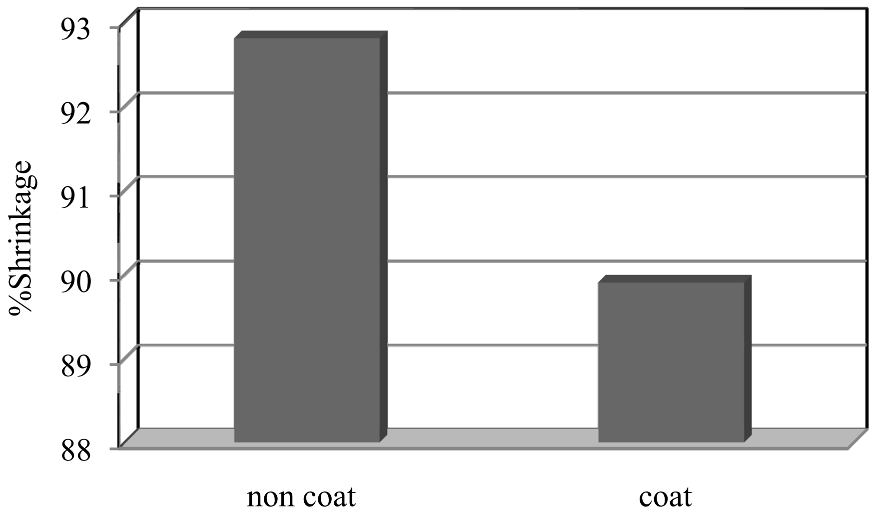

Fig.4: Effect of coating on shrinkage present

True density: The difference in particle density for each food product can be explained by the chemical reactions in the material caused by the collapse of cells and the temperature effects. Generally speaking, a low apparent density indicates a great volume of pores formed during drying (Rahman *et al*., 2002). According to kingsly *et al*. (2006), the true density increased as the moisture content increased as the increase of mass is more compared to the increase in volume. True density of vacuum and freeze dried apple was highest and lowest content. Similar results were reported for dried apple (Mauro *et al.,* 2004), dried yam flours.

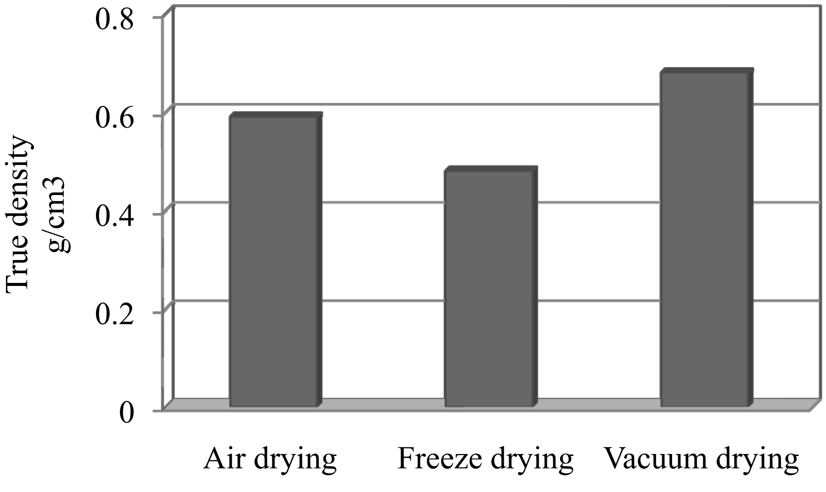

Fig. 5: Effect of drying on the true density of dried apples

Color change: color is often associated with the quality of the product and maybe taken as an indicator of level of natural deterioration of fresh foods (Krokida *et al*., 2000). The higher Color changes (ΔE) represent greater color change from the fresh apple (Seiiedlou *et al*., 2010). Coated samples had the lower ΔE than non-coated samples; Due to more collapse of external cells of non-coated samples with larger solute uptake that causes the lowest diffusivity of water obtain in the non-coated apples at final drying period (Khin *et al*., 2007). It showed that structural destruction affects on color change of samples. As shown (figure 7) the highest and lowest color changes was related to non-coated and vacuum dried and coated and freeze drier samples.

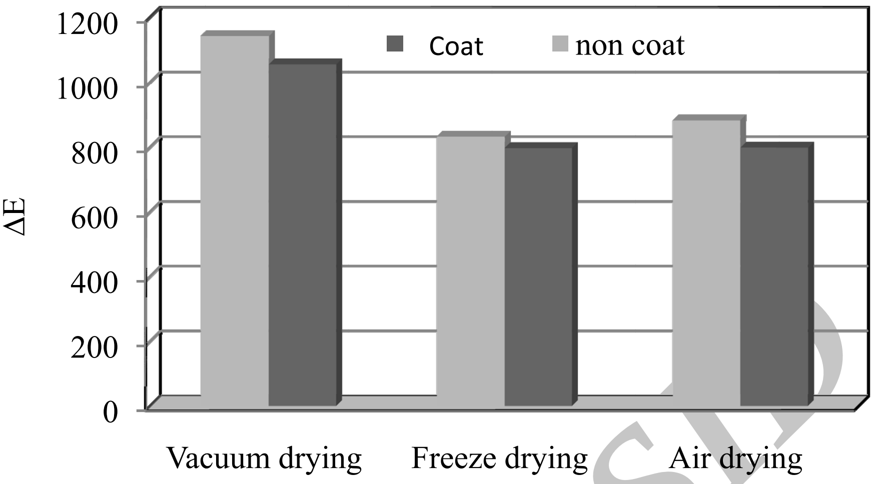

Fig.7: Effect of coating- drying methods on ΔE of dried apples

Shear strength: The moisture content of dried apples with freeze drying, air drying and vacuum drying was 10%, 12% and 14%, respectively. As shown (figure 8), the coated and freeze dried and non coated and vacuum dried samples were the highest and lowest shear strength, respectively. Also, the effect of structural destruction is significant. Similar result was reported for dried carrot (Phongsomboon & Intipunya, 2009). Edible coat causes the increase of shear strength due to decrease of solute uptake to texture of sample. The solute uptake in texture increases brittleness and decreases shear strength (Behrozi, 2008).

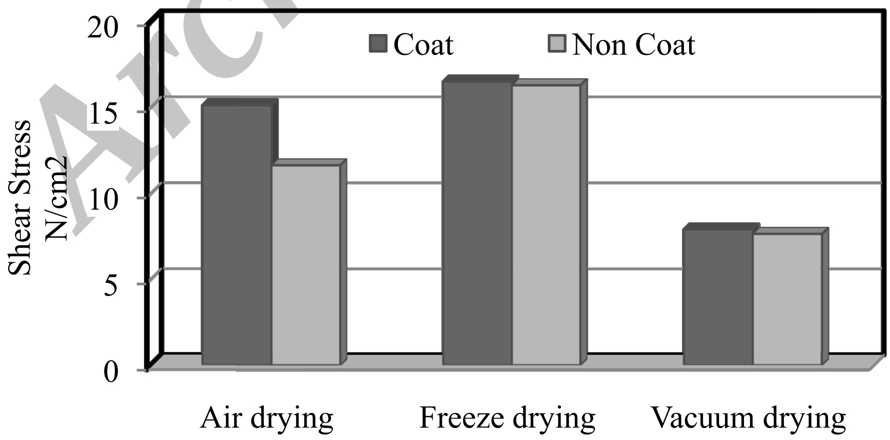

Fig.8: Effect of coating- drying methods on shear strength of dried apples

The results of sensory evaluations (color, chew ability, flavor, appearance, overall acceptability) have been presented in table 2. Comparing of data with Duncan test showed significant different in coating and different drying methods samples as shown in figure 9. The effects of coating and drying methods were significant on the chew ability, taste and overall acceptability.

Table 2: The results of sensory evolution from a 5 points hedonic scale, which ranges from 1 (dislike extremely) to 5 (like extremely) with a panel composed of 9 trained taste panels

	Samples	Taste	Color	Chew ability	Appearance	Overall acceptability
Coat-Osmosis-Air drying	Mean	4.000	3.222	3.667	3.833	3.778
	Std. deviation	0.000	0.441	0.500	0.250	0.441
Coat-Osmosis-Freeze drying	Mean	4.778	4.778	4.889	4.778	4.889
	Std. deviation	0.441	0.441	0.333	0.441	0.333
Coat-Osmosis-Vacuum drying	Mean	2.000	2.444	2.000	3.111	2.111
	Std. deviation	.000	0.527	.000	.333	.333
Non coat-Osmosis-Air drying	Mean	3.444	2.556	2.556	3.111	3.778
	Std. deviation	.527	0.527	.527	.333	.441
Non coat-Osmosis-Freeze drying	Mean	4.000	4.556	3.667	3.778	4.000
	Std. deviation	.000	.527	.500	.333	.000
Non coat-Osmosis-Vacuum drying	Mean	2.333	2.556	2.000	2.111	2.222
	Std. deviation	.500	.527	.000	.333	.441

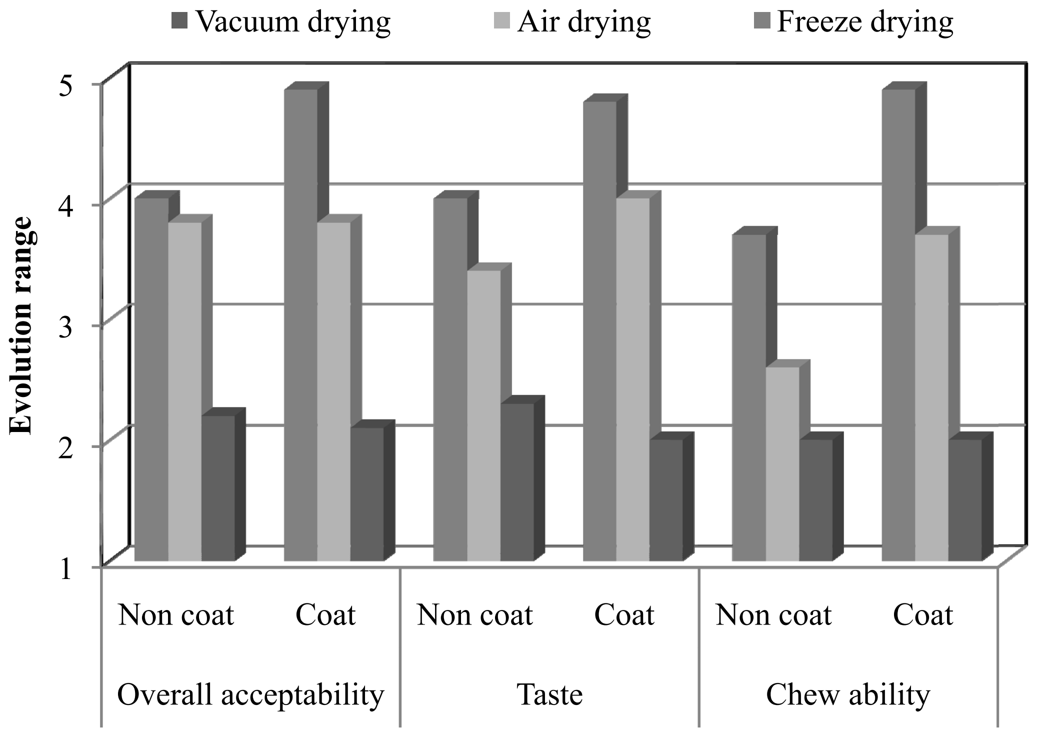

Fig.9: Effect of coating- drying methods on sensory evolution of dried apples

CONCLUSION

Using of edible coat before osmosis process had significant effect on the SS, ΔE, and RR. As coating decreases RR and ΔE and increase SS. Also, drying methods had significant effect on physical properties. The lowest and highest true density, shrinkage present, and ΔE was attributed to freeze and vacuum dried samples, respectively. The freeze and vacuum dried samples had highest and lowest SS, respectively. The air and freeze dried samples had highest and lowest RR. The coated and freeze dried samples had best flavor, texture, and acceptability in sensory evaluations.

ACKNOWLEDGEMENT

Authors acknowledge supporting received from AERI (Agricultural Engineering Research Institute).

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