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Impact of antioxidant edible coatings and osmotic dehydration on shrinkage and colour of "Quince" dried by hot air

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Abstract

Osmotic dehydration is an operation used for the partial removal of water from plant tissues by immersion in a hyper-tonic (osmotic) solution. However, the concern in osmotic dehydration is currently to minimize the uptake of osmotic solids, as it can severely alter organoleptic and nutritional characteristics of the product. To control the amount of solute uptake into the food, we can use edible coating before osmotic dehydration, which acts like a barrier that decreases solute uptake without having negative effect on the rate of water removal. In this study the effect of edible coating pretreatment (based on carboxymethyl cellulose, pectin and ascorbic acid) and osmotic dehydration on shrinkage and colour in the dried "quince" slices were studied. The osmotic samples had less shrinkage than the control and coated samples. Coating and osmotic dehydration caused to decreasing in overall colour change of dried quince which was attributed to decreasing contact with oxygen, reduction effect of ascorbic acid and chelating and pH decreasing effects of citric acid.

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Introduction

Dehydration of the fruits and vegetables is one of the oldest forms of food preservation techniques known to man. Osmotic dehydration is used for partial removal of water from materials such as fruits and vegetables by immersing in aqueous solutions of high osmotic pressure such as sugar and salts. The most commonly used osmotic agents are sucrose for fruits and sodium chloride for vegetables. Osmotic dehydration can be conducted at low temperature and is less energy intensive than convective drying or freezing. The main advantages of osmotic dehydration include better color, texture and flavor retention along with minimum heat damage. Osmotic dehydration is affected by several factors such as osmotic agent, solute concentration, temperature, time, size, and shape and tissue compactness of the material, agitation and solution/sample ratio. (Pandharipande *et al.,* 2012). The simplest and most economic method for dehydration of foods is air-drying; although certain problems such as the considerable shrinkage caused by cell collapse following the loss of water, the poor re-hydration characteristics of dried products and unfavorable changes in colour, texture, flavor and nutritive value may occur a faster dehydration that yields a higher quality production is always required.

A number of drying technique has been developed over year and year such as conduction, convection, and radiation. The simplest and economic method for dehydration of foods is hot air-drying in conventional tray, cabinet or vaccum dryers but these dehydrated products have fewer acceptances since the products quality is considerably reduced. The problems associated with products obtained by air-drying are woody texture, slow or substantial amount of water loss. It also brings about undesirable changes in color, texture, flavor and loss in nutritive value Patil and Kalse (2012). Osmotic dehydration is used for partial removal of water from materials such as fruits and vegetables by immersing in aqueous solutions of high osmotic pressure such as sugar and salts. The most commonly used osmotic agents are sucrose for fruits and sodium chloride for vegetables. Osmotic dehydration can be conducted at low temperature and is less energy intensive than convective drying or freezing. The main advantages of Osmotic dehydration include better colour, texture and flavor retention along with minimum heat damage. Osmotic dehydration is affected by several factors such as osmotic agent, solute concentration, temperature, time, size, and shape and tissue compactness of the material, agitation and solution/sample ratio (Pandharipandeand Antic 2012). To control the amount of solute uptake into the food, we can use edible coating before osmotic dehydration, which acts like a barrier that decreases solute uptake without having negative effect on the rate of water removal. Edible coatings are made of one to four major materials including: lipids, polysaccharides, resins and proteins and also a mixture of these materials forms the new composite edible coatings that can limit lipid, oxygen, water vapor and flavor migration between food and the surroundings. Coating solutions such as low-methoxyl pectinate, high- methoxyl pectinate, methyle cellulose, carboxyl methyle cellulose, maltodexterin, potato starch, corn starch, sodium alginate, chitosan and ethyle cellulose can be used on vegetables and fruits to prevent solid gain and improve Organoleptic properties, shelf-life and nutritive properties during osmotic dehydration (jalaee *et al*., 2010).

Quince fruit (Cydonia oblonga), a member of the Rosaceae family, is known for its characteristic and pleasant odor and distinctive taste. However, like other fruits, they are perishable; therefore drying is fairly advantageous, reducing water activity of the material, thus diminishing the microbiological activity to a level preventing deterioration. Even though the drying is one of the most common methods used to improve (Maria Barroca1 and Raquel 2012); Ingredients of quince 83.8% water and 15.3% carbohydrates (wet basis) are the main constituents of quince. Minor ingredients of quince are proteins (0.4%, wet basis) and fats (0.1%, wet basis). It is presumed to be a good source of fiber, potassium, and vitamin C. The mean of the last 10 years' (1998–2008) world production of quince is estimated to be

510,000 t (Noshad and Mohebbi, 2011).

Abbasi *et al.* (2011) concluded that shrinkage is increased with increasing drying time. In addition, at the same sampling time, the samples undergoing drying at higher temperatures suffer more shrinkage than those undergoing drying at lower temperatures. This is because the drying temperature directly affects the product shrinkage (or deformation); larger moisture gradients within the samples develop in higher drying temperatures and these larger gradients lead to increased internal stresses, which in turn lead to larger degrees of shrinkage. Moreover, the shape of the dried samples was not uniform indicating that the deformation of the samples was not symmetrical. However, the samples dried at air velocity of 1.5 m/s and different temperatures at end of drying time were not much different in terms of the percentage of shrinkage. This is because case-hardening occurred more at the surface and limited the shrinkage of the samples. Initially, the percentage of shrinkage increases rapidly. This is followed by a period of slow increase until reaching the final values at the time corresponding to the points where the samples reach their equilibrium moisture contents.

The objective of this work is to improve the shrinkage, color and sensory evolution of dried quince slices by adding edible coating and osmotic dehydration pretreatments to the hot-air drying method

Materials and methods

Materials

Fresh quinces (varieties of Sharafkhane) were purchased at local market in Tabriz, Iran. Carboxymethyl cellulose (Food chem, China, Viscosity 2280, Degree of substitution0.82), low methoxyl pectinate (LMP, degree of esterification: 31.5%, Degussa, Pullach, Germany) and ascorbic acid (Northest pharmaceutical, China) were used as polysaccharide-based edible coatings. Glycerol (Sigma-Aldrich, Germany) was applied for plasticizer. Calcium chloride (Sigma-Aldrich, Germany) was added for gel forming and cross-linking. Fructose (Krueger, Germany), Calcium chloride (Sigma-Aldrich, Germany) and citric acid (Kaselcit, China, $C_6H_8O_7.H_2O$) were used as osmotic solution formulations. Toluen (C7H7, Iran, melting point 111°C, Density of solvent 0.866- 0.868).

Preparation of samples

Quinces (varieties of sharafkhane) were purchased from a local supermarket (produced in sharafkhane, Iran) and stored at 4 °C. A single batch of quinces was used in the experiments, which were restricted to a period of time. Because of the ripening of the quinces, it was always ensured that firm quinces were selected for dehydration experiments. For all experiments quinces were washed and sliced (40mm diameter, 2mm thickness) with two special cutting tools. Initially, in order to avoid undesirable enzymatic reactions and improve structural properties, quince slices were blanched in hot water (80 °C for 1min).

Coating treatment

The slices of quinces were immersed in optimized coating solutions resulted from our previous research works by RSM (1.49% carboxymethyl cellulose, 1.49% pectin and 0.58% ascorbic) (w/v) for 3 minutes. Then they were dried at 55-60°C for 5-10 minutes, in order to fix the coating on the samples. for preparation of coating solution, carboxymethyl cellulose, pectine and ascorbic acid powder was dissolved in distilled water by heating the mixtures using the stirring hot plate (70°C) until the solutions became clear and then glycerol as plasticizer was added to the solutions (Tapia *et al.*, 2008; Azarakhsh *et al. et al.*, 2012). The overall volume for each formulation was 1000 ml and this includes amounts of CMC, pectine and ascorbic acid, 0.2 %(w/v) glycerol and the rest was distilled water. For cross-linking of polymers a 1% (w/v) calcium chloride solution was used (Montero-Calderon *et al.*, 2008).

Osmotic treatment

Osmotic dehydration was carried out (for coated and non-coated samples) in optimized osmotic solution that resulted from our previous research works by RSM (fructose 50%, calcium chloride 5%, acid citric 3%) (w/v), under temperature of 25 ^{o}C (The temperature was monitored by the thermocouple and was set at 25 °C). A sample to solution ratio of 1:10 (w/w) was used in order to avoid excessive dilution of the osmotic solution during processing (Khin *et al.,* 2006). The optimom immersion time in osmotic solution was determined about 180 minutes by previous test (kinetic of osmose) (Khin *et al.*, 2006). Non-coated quinces were also dehydrated osmotically under the same conditions as for coated quinces, for comparing different behaviors after drying.

Hot-air Drying

After osmotic treatment, drying of samples was performed in a laboratory tray-dryer (Arm field, England) at an air temperature of 60°C and air velocity of 1.5 m/s, in Chemistry faculty of Tabriz university. Before each drying experiment, the drier was run without sample for about 30 min to set desired conditions. The quince samples pretreated with edible coating and osmotic dehydration were subjected to air-drying at 60 °C. Air-drying was carried out for 4, 5, and 6 h to reach 0.2 kg/kg moisture content by the same above mentioned hot-air drier. Finally, the moisture content of dried quince was determined upon AOAC method 931.04 (AOAC 1990). The experiments were conducted with three replications (Noshad & Mohebbi, 2011).

Analytical methods

Determination of shrinkage

Percentage of shrinkage was determined from the changes of the bulk volume of the quince slices using the liquid displacement method (Ko *et al.* 2008). In this study, toluene was used instead of water because it caused reduction of liquid absorption into the fruits.

$$SH = \frac{V_0 - V}{V_0} \times 100 \qquad (1)$$

Where V_0 and V are initial and final volume of the sample (Noshad *et al.*, 2011).

Colour Measurements

Colour parameters were measured (Chroma index, L, a, b, ΔE). The parameter L represents the brightness of the colour, a hue range of the colours red (+) and green (-) and b hue range of colours yellow (+) and blue (-). The colour measurements were made on the surface of fresh sliced quince before and after drying and the average values were made for calculation and each treatment was representing by three replicates. Total colour change (ΔE), chroma (C), was calculated using equations described by Maskan (2001) and Omayma (2012).

$$\Delta E = ((L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2)^{1/2} \qquad (2)$$

$$Chroma = (a^2 + b^2)^{1/2} \qquad (3)$$

Where; subscript "o" refers to the colour reading of fresh quince slices. Fresh quince was used as a reference and a larger ΔE denotes greater colour change from the reference material (Maskan, 2001; Omayma, 2012).

Statistical analysis

One-way ANOVA test was used to analyze the results to determine if the difference was significant. The data were analyzed using one-way analysis of variance at $P < 0.05$ significance with SPSS software (SPSS Ver.16.0.0, 2007; SPSS Inc., Chicago, IL, USA). Duncan's multiple range tests were conducted to determine the statistical differences among treatment means. For determine parameters of color, we used MATLAB 2011. All experiments were carried out in triplicates.

Results and discussion

Determination of shrinkage

The effects of coating and osmotic dehydration on the shrinkage of samples are represented in Fig. 1. The use of coating, osmotic dehydration or both of them will decrease the amount of shrinkage. Fig. 1 also indicates maximum shrinkage was observed in control. With respect to Fig.2 we can concluded that coating and osmotic dehydration had positive effect on shrinkage of dried quince.

Lewicki *et al.* (2002) investigated the effect of osmose and calcium cloride as pre-treatments in drying of tomato. They concluded calcium cloride increased the rates of convective drying and osmotic dewatering as well. Their results showed that calcium chloride and osmotic dehydration lead to increase the rates of convective drying, water loss, reduced the time of final drying and prevent the shrinkage of samples. Pre-treatment with $CaCl_2$ increased by 20% the amount of water removed during osmotic dehydration and facilitated infiltration of sucrose. Treatment with $CaCl_2$ followed by osmotic dewatering was more effective than osmotic treatment done in the presence of calcium chloride.

Table 1. Colour parameters of samples.

Samples	L	a	b
Control (1)	0.73 ab± 47.598	-9.3005± 2.51 c	41.1242 ±4.75 b
Coated samples (2)	47.153 ±2.46 ab	-7.4653±3.00 ac	45.04545±3.67 b
Osmotic samples (3)	43.898±2.19 b	-2.3153±1.19 a	45.713±2.12 b
Coated and osmotic samples (4)	49.304±0.08 a	-5.5391±0.05 ac	52.6262±0.01 a

(Fresh fruit: L_o= 48.6063, a_o= -7.5824, b_o= 53.1909) Different letters showed significant difference between samples in duncan test (P<0.5%).

Tavakolipoour *et al.* (2008) were investigated the effect of edible coatings (pectin,carboxy methyl cellulose, corn starch) on the quality, physicochemical properties and sensory of osmotic dried apples (in 2 levels of concentrations of sucrose as osmotic agent). They reported the shrinkage rate of osmotic product was lower than those were dried with hot air drying directly. The lowest shrinkage was for samples coated with 1% and 0.5% pectin.

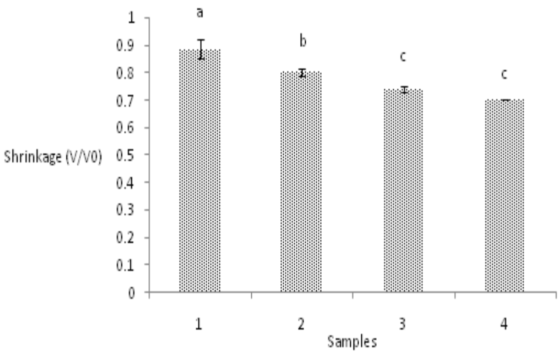

Fig. 1. Dried quince shrinkage examined: (1) control (2) coated sample, (3) ucoated _osmotic dehydrated sample (4) coated _osmotic dehydrated sample. Different letters showed significant difference between samples in duncan test (P<0.5%).

Abbasi *et al.* (2011) concluded that drying time divides the periods of shrinkage variation into the rapid increase and slow increase (followed by a constant value) periods. Towards the end of drying, case hardened skin develops which inhibits further shrinkage of the samples. The samples undergoing hot air drying at higher temperatures possess higher rates of shrinkage than those of samples undergoing drying at lower temperatures.

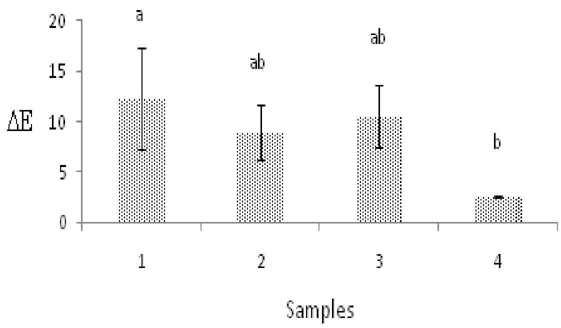

Fig. 2. Dried quince color changes (ΔE) examined: (1) control (2) coated sample, (3) ucoated _osmotic dehydrated sample (4) coated _osmotic dehydrated sample. Different letters showed significant difference between samples in duncan test (P<0.5%).

Colour measurement

Colour parameters are shown in table (1) and figurs. (2 , 3) indicate colour chang and chroma index of control and pre-treated and dried quinces. Due to table (1), coated and osmotic samples have maximum parameter L (i.e lightness of colour) and edible coating and osmotic dehydration reduce green (parameter a) and enhanced yellow color (parameter b) of the samples. As can be seen in Figure 2, coated and osmotic samples are less colour change (ΔE) than other samples. Between these samples and other samples, there are significant differences at the 5% level. This reduces the amount of color change can be seen in coated and non-osmotic dehydrated samples, in general, we can say that the color differences of coated samples were lower than the non- coated samples. Enzymatic browning is one of the effective factors in color change of fruits and vegetables during storage and drying. On the other hand, edible coatings can reduce the contact of fruits tissues and oxygen and delay the progression of this reaction. Also the use of reducing substances such as ascorbic acid can be effective in preventing the formation of ortoquinone and enhance the inhabition. Evaluation of color has been made by other researchers. In most studies, changes color for osmotic samples was less than non- osmotic samples during hot air drying. The reason for this, can be attributed to sample placed in the osmotic solution and away from the oxygen. Also chelating agents such as citric acid can also be reduced enzymatic activity of phenolase by blocking of copper ions and reducing of pH, And also the browning rate of final product is reduced by increasing the osmotic solution concentration (Hadad khodaparast, 2008 Sowti *et al.,* 2003). Osmotic process reduced the need to use of sulfur compounds to prevent colour change (Krokida, 2000).

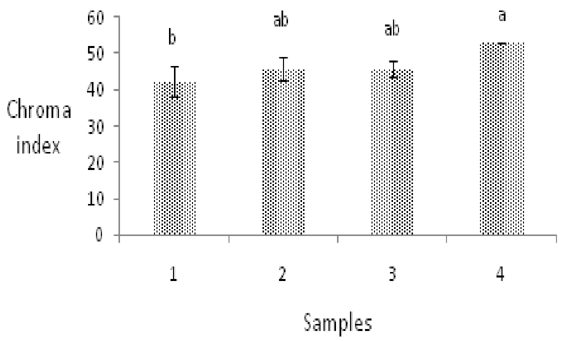

Fig. 3. Dried quince chroma index examined: (1) control (2) coated sample, (3) ucoated _osmotic dehydrated sample (4) coated _osmotic dehydrated sample. Different letters showed significant difference between samples in duncan test (P<0.5%).

As you can see in Figure 3, chroma index for coated and osmotic samples is the highest value and in the duncan test, there is significant difference at 5% level with the other samples and in the duncan test, there is significant difference at 5% level with the other samples. Furthermore the chroma index or color intensity for control is the minimal rate but have not significant differences with other samples (except coated and osmotic samples).

Conclusion

The effect of edible coating and osmotic dehydration pretreatments (before final drying) on shrinkage and colour in the dried "quince" slices were studied. Coating and osmotic dehydration caused to decreasing in overall colour change of dried quince which was attributed to decreasing contact with oxygen, reduction effect of ascorbic acid and chelating and pH decreasing effects of citric acid. Furthermore, control and coated samples had more shrinkage than the osmotic samples.

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