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Effect of Different Pre-Drying Treatments on The Quality of Dried Apple Slices

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THE EFFECT of pre-treatment such as osmotic dehydration (OD), honey immersion (HI), citric acid dipping (CD), steam blanched (SB), and sulfiting in sodium-metabisulfite (SU) of apple slices on physicochemical, sensory and antioxidant properties were studied. Chemical composition, total phenols, Vit (C), antioxidant activities and sensory evaluation were tested for all treatments. Results Showed that SB pre-treatment had the lowest percentage of moisture content and the highest percentage of total soluble solids (TSS).Sulfiting pretreatment had the maximum value of ascorbic acid, total phenolics content (TPC) and antioxidant activity (AOA). Sensory evaluation of dried apple slices showed that SU and HI treatments had the best value of taste and texture. Furthermore, HI had the best value of odor, while SU treatment had the best value of color. The main objectives of the present study were to determine and compare the effect of different pretreatments on physiochemical properties and sensory attributes of dried apple slices.

Keywords: Apple, Osmotic dehydration; Physicochemical, Phenolic content, Nutrition value, Antioxidant activity and Sensory evaluation.

Introduction

Apple is a rich source with bioactive compounds like polyphenols (Boyer and Liu, 2004), that given the sensory and antioxidant properties of the fresh and processed apples (Van der Sluis etal., 2002). The polyphenols antioxidant contents of the apple play important role in the biological system by chelating some of metal ions such as iron and copper and denoting the hydrogen-ions, consequently, scavenging the accumulated harmful free radicals from the body. So, they protect the tissues from the oxidative damaging (Balasundram et al., 2006).

The dryness of food means the dehydration process which reducing the moisture content of food resulting in microbial growth retardation and inhibiting chemical deteriorationwith great reduction of the net volume of the product (Doymazand Pala, 2003).The dryness of fresh fruits and vegetables is widely used over man's life for becoming available for consuming regardless the season of its production. In this context, plant tissue is usually subjected to certain pre-treatments before drying in order to minimize adverse changes occurring during preparation, drying and subsequent storage such as darkening. Many light-colored fruits, such as apples are darkening rapidly when cutting and exposed to air, otherwise these fruits will continue to darken after drying (Piotr, 1998). There are many drying pre-treatment processes commonly used in food such as osmotic dehydration, honey Immersion, citric acid dipping, steam blanching and sulfating. Dried apples are widely used as a human food in the form of breakfast foods, snack preparations, infant food and others (Akpinar et al., 2003).

The osmotic dehydration pre-treatment reduces the moisture content of food and consequently reduces air-drying time up to 65% depending on the used dehydrator (Ruiz et al.,

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2010). Furthermore, osmotic dehydration is achieving product stability, retention of nutrients and improvement of food odor and texture at ambient temperature with minimal damaging effect on food quality as well as it has an enzymatic oxidative browning effect, which results in less discoloration of fruits (Torreggiani, 1993 and Velic´ et al., 2004). Mundada, et. al. (2011) stated that pomegranate arils soaked in 60 °Brix sucrose solution showed higher solid gain and water loss as compared to the samples soaked in 40°and 50° Brix's osmotic solution.

Honey has several pharmacological properties such as prebiotic activity (Sanz et al., 2005), antioxidant effect (Frankel et al., 1998), antibacterial effect (Weston and Brocklebank, 1999), andanti-mutagenic effect (Wang et al., 2002). So, it is widely used for health-improving substance. Honey Immersion had been used to enhance the osmotic dehydration process of food, as honey sugar consists of fructose, glucose, maltose, sucrose and other carbohydrates, so it is used widely as a natural sweetener in functional food for making the produce more acceptable to human, particularly to children.The honey solution has a high osmotic pressure that permits rapid water diffusion in comparing with single sugar solutions. Further more,it provides a better plasticizing effectand better rehydration properties (Zhou and Jiang, 2009).

Dipping in citric acid solution had been used as a drying pretreatment method in food. The respiration rate of sliced potatoes is decreased by dipping them in 2.5% citric acid solution(Limbo and Piergiovanni, 2007),and the dried slices of apple previously treated with citric acid solution are lighter than those treated with ascorbic acid (Beatrix et al. 2011) because the dippingin citric acid solution decreases the enzymatic browning effect (Robbers et al., 1997).

Thermal blanching is an essential operation for many fruits and vegetables processing. It does not only contribute to the inactivation of polyphenol oxidase and peroxidase, but also affects other quality attributes of products. The purposes of blanching, which include inactivating enzymes, enhancing drying rate, removing pesticide residues and toxic constituents, expelling air in plant tissues and decreasing microbial load (Xiao et al., 2017)

An important pretreatment method used for many fruits and vegetables drying is called thermal blanching, which includes steam blanching and water blanching. The thermal blanching process of fruits and vegetables inactivates the polyphenol oxidase and peroxidase enzymes, enhances the drying rate, removes pesticide residues and toxic constituents, expels air in plant tissues and destroys and reduces microbial load (Xiao et al., 2017). The steam blanching is inexpensive and conserves most minerals and watersoluble components within dried food due to the negligible leaching effects that occurs in water blanching (Royal et al., 2009) , but the disadvantages of steam blanching process are softening tissue texture, loss of soluble nutrients, pigment and aroma because of long heating time in steam blanching, especially when the velocity of the steam is very low. In order to reduce the nutrition loss of treated fruits and vegetables during thermal blanching, a new, more efficient blanching treatmentsuch as high-humidity hot-air impingement blanching is used now (Deng et al., 2017).

Many years ago, Sulfuring and sulfiting by using sodium bisulfite, sodium sulfite or sodium meta-bisulfite (food grade) compounds, had been used to avoid enzymatic and non-enzymatic browning and decrease the spoilage during the preparation, dehydration, storage, and distribution of many foods as they have an antimicrobial effect as well as preserve the color of some dried fruit products (Jayaraman and Das Gupta, 1995 and Lewicki, 1998).

This paper aims to compare the different pre-drying treatment processes, such as osmotic dehydration (OD), honey immersion (HI), citric acid dipping (CD), steam blanching (SB), sulfiting (SU), on the quality of dried apple.

Materials and Methods

Materials

Fresh apple fruits (*malus domestica*) were purchased from a local supermarket in Fayoum, Egypt. The fruits were washed in water and stored in refrigerator at 4°C ±1 until processing. All chemicals and solvents used in this study were analytical grade.

Methods

The fruits were washed, peeled and cut manually into similar slices. The thickness was approximately similar (5-6 mm). At least three samples were taken from each apple to minimize fruit-related components of variability.

Apple slices weredivided into six groups: the first group (CO)was the control. In the second group (SB) apple slices was blanched with steam. Slices in the third group were dipped in sucrose solution (40%) at room temperature (OD) for two hours, while in the fourth group the slices were dipped in honey solution (1:1 honey : water) (HI) for two hours also. The slices in fifth group were soaked in 0.5 % citric acid for 10 min (CD). In the last group slices were dipped in (200 ppm) sodium meta-bisulfite (SU)for 10 min. Then, all treatment's slices were drained, blotted with absorbent paper to remove any excess solutions. Finally, samples were dried in the oven at 60°Ctill completely drying.

Chemical evaluation

Moisture and ash content were determined using oven method and muffle furnace according to (AOAC, 2000). Vit C was determined using the method in presented in AOAC, 2000. Total titratable acidity (TTA) was measured by diluting approx. 5 g of dried apple in 100 ml of distilled water and adding 3–4 drops of phenolphthaleinindicator. The solution was then titrated with a 0.1 N NaOH solution beyond pH 8.1 The TTA was calculated as a percentage of malic acid.

Determination of total phenolic content

The Folin–Ciocalteu method was used to determine total phenolic content (Singleton, et al., 1999) using Folin– Ciocalteu reagent. The total phenolic content was determined by comparing with a standard curve of gallic acid (10–200 µg/ml; $Y = 0.025X + 0.2347$; $R^2 = 0.9986$). The mean of at least three readings was calculated and expressed as mg of gallic acid equivalents (mg GAE)/100 g of apple slice extract.

Identification of phenolic compounds by HPLC

The separation of phenolic acids and flavonoids were performed with an Agilent 1260 Infinity series HPLC system equipped with on-line degasser (G 1322A), quantum (G 1311C), auto sampler (G 1329B), column heater (G 1316A), and variable wave length detector (G 1314F). Instrument control and data analysis was carried out using Agilent HPLC Chem Station 10.1 edition through Windows 7. Column Zorbax C18 (5 µm, 4.6 mm × 150 mm, Agilent) was used. The flow rate of the mobile phase was kept at 0.5 mL/min. Mobile phase A was water containing 0.02% TFA, and phase B was methanol containing 0.02% TFA. The gradient conditions were as follows: 0-5 min, 25% B; 5-10 min, 25-30% B; 10-16 min, 30-45% B; 16-18 min, 45% B; 18-25 min, 45-80% B; 25-30 min, 80% B; 30-40 min, 80-25% B. The temperature of column was controlled at 25 °C. Injection volume was 20 µL. The detection wavelengths were set at: 280. Prior to each run, the HPLC system was allowed to warm, and the baseline was monitored until it was stable before sample analysis.

Determination of radical scavenging activity

The free radical scavenging activity was analyzed using the 1,1-dipheny-2-picrylhydrazyl (DPPH) assay according to Brand-Williams, Cuvelier, &Berset, 1995. The scavenging or inhibition percentage was calculated according to the following equation:

Scavenging (%) = [(abs. control – abs. sample) / abs. control] X 100

Where: abs. is absorbance at 515nm. Inhibition of coloration was expressed as a percentage, and the effective concentration 50 % (EC_{50}) was obtained from the inhibition curve.

Sensory evaluation

Sensory properties including color, texture, odor and taste for dried apple slices were determined by staff members of Food Science and Technology Department, Faculty of agriculture, Fayoum University, Egypt, using the hedonic scale method rating of 1 – 10 (1= dislike very much, 10 like very much).

Statistical analysis

Statistical Package for Social Science (SPSS) version (17) was used to analyze data obtained. Differences between mean values with probabilityp < 0.05 were recognized as statistically significant differences.

Results and Discussion

There are many ways in which drying pre-treatment of apples are processed. One of the purposes of our experiment is to study its effect on the quality of dried apple fruits. In this context, moisture content (MC), total soluble solids (TSS) and ash% were studied.

The initial moisture content of the fresh apple samples was in the range 6.96 –9.59 % (Table 1), the highest percentage of moisture content was recorded in citric acid dipping pre-drying treatment while the lowest value of moisture content was recorded in steam blanching treatment.

These results are parallel with Glinka and Reinhold (1972) due to the increased permeability of cells to water when the cells are dead by steam blanching.

There is apparent direct relationship between MC and TSS in all pre-drying treatments of apple fruits. Table 1 showed that the highest value of TSS was93.19 % in steam blanching treatment while the lowest value of T.S.S was 90.41% in citric acid dipping treatment may be due to attributeto the dilution effect of wateruptake.

Concerning Ash percentages, its range was (2.85-1.40%) (Table 1). In fact, the maximum value 2.85% was recorded in sulfiting pre-dryingtreatment may be due to the presence of sodium metabisulfite in apple tissues, while the minimum value1.40% was recorded in Immersion in honey pretreatment, other treatments had low percentages of ash may be due to the immerse in liquid whether steam, acid, honey and sucrose solution resulting in a reduction of minerals content.

From Fig. 1, it was clear that the acidity expressed as malic acid was ranged from (0.21 - 2.48 mg/100g), the highest value was recorded in citric acid pre-dipping treatment because of using citric acid which increase the acidity, while the lowest value was recorded in immersion in honey pretreatment due to the neutrality effect of the honey. Similar results were obtained by Phisut, 2012 who revealed that osmotic dehydration maximizes the sugar to acid ratio and enhances the stability of pigments and texture during drying and storage.

The aforementioned results in Fig. 1 revealed that the lowest pH value was observed in citric acid dipping pretreatment which was 4.35, this could be attributed to the use of citric acid while the highest value was 5.41 found in sulfiting pretreatment.

The obtained results as shown in Table 2 revealed that treatment by osmotic dehydration has the maximum value of total sugars and non-reducing sugars11.28% and 6.26 % respectively, and immersion in honey pretreatment as result of the close 4.78 and 10.68% respectively. Such finding coincides with that obtained by Phisut, 2012 who found that the sugar uptake in osmotic dehydration technique of low molar mass saccharides (glucose, fructose and sucrose) is high due to the maximum diffusion rate of molecules.

While steam blanching treatment has the minimum value of both total sugars and non-reducing sugars7.62 and 3.24 % respectively.

From Table 2, it was clear that treatment by citric acid dipping has the highest value of reduced sugars 5.28 %, while sulfiting pretreatment has the lowest value 4.042 %, and other pretreatment have value range from 5.28 -4.04%.

Total phenolic content and antioxidant activity assays.

Ascorbic acid is usually selected as the frequently measured nutrient to evaluate the nutrient losses during pre-drying treatmentsprocess. As shown in Table 3, sulfiting pretreatment has the highest value of ascorbic acid(1.67 mg/100g). Such finding coincides with that obtained by (Jayaraman and Das Gupta, 1995) who found that sulfiting is the most effective additive to avoid protects food components liable to oxidation as ascorbic acid oxidation,While the lowest value of ascorbic acid was (0.45 mg/100g) in the apple slices without treatment (control). These results can be explained in the light of published report indicating that ascorbic acid loss during steam blanching and samples without pretreatment is due to thermal degradation and enzymatic oxidation (Xiao, 2014). On the other hand, fresh samples without treatment and drying has a higher level of ascorbic acid (more than three folds) than the treated samples.

TABLE1. Effect of pre-drying treatments on moisture content, total soluble solids and ash % of treated slices apple

Component%	Pre-treatments					
	CO	SB	OD	HI	CD	SU
Moisture content	8.47	6.80	8.87	6.96	9.59	8.27
Total soluble solids	91.53	93.19	91.13	93.04	90.41	91.72
Ash	1.93	1.54	1.52	1.40	1.54	2.85

OD:osmotic dehydration, HI: honey immersion, CD: citric acid dipping, SB: steam blanched, SU: sulfiting.

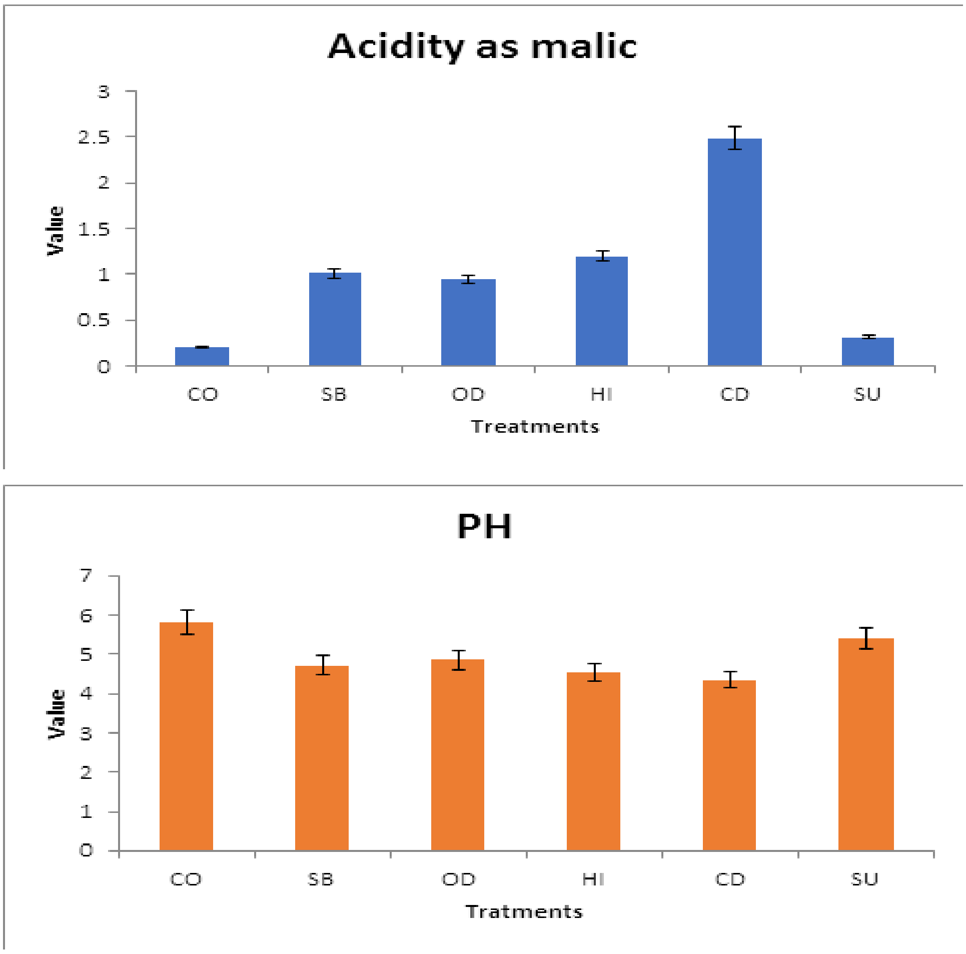

Fig.1. Acidity and pH values of sliced apple samples

TABLE 2. Effect of pre-drying treatments on total sugars, non-reducing sugars and reducing sugars % of dried slices apple

Component%	Pre-treatments					
	CO	SB	OD	HI	CD	SU
Total sugars	8.14	7.62	11.28	4.78	9.72	4.76
Non-reducing sugars	3.94	3.24	6.26	10.68	4.44	8.80
Reducing sugars	4.20	4.37	5.02	5.90	5.28	4.04

OD:osmotic dehydration, HI: honey immersion, CD: citric acid dipping, SB: steam blanched, SU: sulfiting.

TABLE 3. Effect of treatments on vit.c, total phenolic content and antioxidant activity as expressed by IC50

Treatment	Vit C mg/100g	Total Phenolic mg/100 g as G.A	IC50 mg/100g
Co	0.45	7.72	0.42
SB	0.53	7.81	0.5
OD	1.11	4.64	0.38
HI	1.15	6.89	0.5
CD	1.55	10.31	0.55
Su	1.67	13.41	0.54

OD:osmotic dehydration, HI: honey immersion, CD: citric acid dipping, SB: steam blanched, SU: sulfiting.

The results for the total phenolics content (TPC) andantioxidant activity (AOA) assays (DPPH) of fresh and dried apples with severalpre-drying treatments are presented in Table 3 sulfiting pretreatment has the maximum value of TPC and AOA (13.41and 0.54 mg/100 g respectively),sulfiting is the most effective drying pretreatments to avoid enzymatic and nonenzymatic browning (Jayaraman and Das Gupta, 1995) resulting in the preservation of phenolic compounds.

In comparison to other pretreatments, osmotic dehydration and honey immersion have the minimum values of TPC (4.64 and 6.89 mg/100 g respectively) and AOA (0.38 and 0.50 mg/100 g respectively).The reduction was may be caused bylosing of the most phenolic compounds inapples such as procyanidins and epicatechin (Christian et al. 2011). Such finding coincides with that obtained by Mavroudis et al. (2004) who found that cell death occurs when the first thin layer of apple tissue is exposed to hypertonic solutions. Cell death can cause an uptake of solids and a release ofinner cellular components, which could cause a leakingin certain compounds and therefore a lower polyphenolconcentration.

Sensorial evaluation

A sensorial evaluation was done to determine the quality of the dried apples in terms of color, taste, odor and texture. Table 4 shows the organoleptic evaluation of dried apple treated by different pre-dried treatment.

Sulfiting pre-treatment has the best color (mean 9.367) and issignificantly higher ($P \leq 0.05$) than the other treatments. No significant different between pre-treatments (sugar immersion, honey immersion and steam blanching). The results in the present study are consistent with that recorded by Jayaraman and Das Gupta, 1995,who noticed that sulfiting inhibits enzymatic and non-enzymatic browning.

For the taste character, there was no significant difference ($P \leq 0.05$) in the taste of the samples from the sulfiting (mean 9.300) compared to the taste in the honey immersion (mean 8.967), that may be attributable to the honey content, resulting in the sweet taste and subsequent preference by panelists. These results run with that published by (Abano et al., 2013). The high-quality apples are dependent upon the taste particularly the sweetness and the acidity (Christian, et al., 2011). While the taste character in these two pre-treatments(SU and HI) was significantly different ($P \leq 0.05$) with other pre-treatments samples.

Texture is one of the most important quality criteria for food acceptability by consumers, especially for dried products. Table 4 demonstrated that there is no significant difference between pre-drying treatments (steam blanching, sugar immersion, honey immersion and sulfiting), while texture character was significantly different ($P \leq 0.05$) in the other treatments (dipping in citric and control). Samples treated by steam blanching, sugar immersion, honey immersion and sulfiting have Crushed edges, the lower the moisture content, the higher the hardness (Alex and Monika, 2014). Phisut (2012) found that osmotic dehydration maximizes the sugar to acid ratio and enhances the stability of texture during drying and storage.Such findings coincide with that obtained by Riva and Masi, 1988 who found that apple disks soaked in citric before drying showed continuous shrinkage of the sample during water evaporation

TABLE 4. Sensory evaluation of dried treated apple slices

Treatments/	Color	Odor	Taste	Texture
CO	7.767^{d}	7.367^{c}	7.600^{d}	7.533^{b}
SB	7.333^{c}	7.767^{c}	7.533^{d}	8.633^{a}
CD	8.233^{b}	8.967^{ab}	8.233^{c}	7.800^{b}
SD	7.567^{c}	9.300^{a}	8.733^{bc}	9.033^{a}
HI	7.600^{c}	9.067^{ab}	8.967^{ab}	9.033^{a}
SU	9.367^{a}	8.567^{b}	9.300^{a}	8.667^{a}

OD:osmotic dehydration, HI: honey immersion, CD: citric acid dipping, SB: steam blanched, SU: sulfiting.

Conclusions

The pre-treatment of apple slices before drying with sulfiting (SU) was the best pre-treatment as it has the highest values for both ascorbic acid, total phenolics content (TPC) and antioxidant activity (AOA). Concerning to the taste and textures, apple slices pre-treatment with HI and SU was the best. The best color of apple slices in different pre-treatments was observed in the SU pre-treatment. Immersion in citric, honey and sugar have no significant difference in odor character (8.967,9.300 and 9.067 respectively), while these treatments have significantly difference (P≤0.05) with other treatments (steam blanching, sulfitng and without treatment).

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تأثير المعاملات الأولية المختلفة علي جودة شرائح التفاح المجفف

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تم دارسة تأثير المعاملات الأولية مثل التجفيف الاسموزي والغمر في العسل والنقع في حامض ستريك والسلق بالبخار والكبرتة باستخدام صوديوم ميتا باي سلفايت على الخواص الفيزوكيميائية والخصائص الحسية والنشاط المضاد للأكسدة لشرائح التفاح المجفف. التركيب الكيميائي والفينولات الكلية وفيتامين سي والنشاط المضاد للأكسدة والتقييم الحسي تم دراسته لكل المعاملات بعد تجفيف شرائح التفاح. أظهرت النتائج أن شرائح التفاح التي تم سلقها قبل التجفيف لها محتوي رطوبى منخفض ومحتوي مرتفع من المواد الصلبة الغير ذائبة عن بقية المعاملات. شرائح التفاح المعاملة بصوديوم ميتا باي سلفايت كانت لها القيمة القصوى من فيتامين سي والمحتوي الفينولى والتأثير المضاد للأكسدة. أظهر التقييم الحسي لشرائح التفاح المكبرتة والمغمورة في العسل أفضل النتائج من ناحية الطعم والملمس حيث كانت الشرائح المكبرتة أفضل في اللون بينما الشرائح المغمورة في العسل كانت أفضل في الرائحة. لذلك يهدف هذا البحث الي دراسة ومقارنة المعاملات المختلفة قبل التجفيف على خصائص شرائح التفاح.