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Effect of anti browning agents and slice thickness on drying and quality of apple slices *var*. Red Chief

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Abstract

Apples of Red Chief variety after stabilization at room temperature (20±2 °C) were initially washed with chlorinated water (100 ppm sodium hypochlorite) to prevent surface contamination. After manual peeling, apples were cut in to disc shaped slices of 2 and 3 mm thickness (having uniform diameter of 20 mm) and treated with 1% ascorbic acid and 1% citric acid (anti browning agents) for studying their effect on drying time and quality of apple slices. Slice size and pre-drying treatments of ascorbic acid and citric acid has resulted in significant (P<0.05) variation for drying time, rehydration, dry matter contents, firmness, quality and total colour change. Significantly minimum time (300 minutes) for drying of apple slices, maximum rehydration ratio (4.9), and maximum firmness (11.9 RI) was recorded in case of 2 mm slices treated with 1% ascorbic acid and 1% citric acid. Maximum TSS (18.9° Brix) was recorded in 2 mm slices and 3 mm slices (18.7° Brix) treated with citric acid and ascorbic acid. Ascorbic acid and citric acid were effective to stabilize the ascorbic acid content and maximum (18.0 mg/100g) was recorded in case of slices of 2 mm thickness treated with 1 % ascorbic acid and 1% citric acid. Similarly size of slices and anti browning agents were significantly effective to reduce the total colour change in apple slices and minimum colour change was observed in 2 mm slices (10.0) treated with 1 % ascorbic acid and citric acid and 3 mm slices (12.25) treated with 1% ascorbic acid and 1% citric acid. It can be concluded that apple slices of 2 mm thickness and pre drying treated with 1% citric acid and 1% ascorbic acid as anti browning agents took minimum time for dehydration with minimum changes in colour, firmness, quality, and retained maximum compositional attributes with minimum browning.

Key words: Apple, Red Chief, anti browning agents, drying, quality, ascorbic acid, citric acid

Introduction

The apple is an important raw material for many food products and is commercially cultivated in many countries of the world. Thus, it is very important to define the conditions under which the characteristics of fresh apples can be preserved and to define optimum parameters for their storage and further use in processing for value added products (Velic *et al.,* 2004). Dried fruits have a long shelf life and therefore can provide a good alternative to fresh fruit, allowing out of season availability.

It is necessary to develop and expand the availability of high quality and consumer attractive dried products (Contreras *et al.,* 2008) with acceptable colour, shape and good rehydration characteristics. Drying is the oldest method of preserving food and also a widely used method for fruits and vegetable preservation that works with removing water from the food, thus preventing the growth of micro organisms and decay. Water is removed to the final concentration ensuring microbial stability of the product and minimizing chemical and physical changes of the material during storage. In most drying processes, water is removed by convective evaporation in which heat is supplied by hot air (Lewicki and Jacubazyka, 2004). Drying behaviour is basically influenced by a number of internal (*e.g.* density, permeability, porosity, sorption-desorption characteristics, thermo physical properties) and external parameters (*e.g.* temperature, velocity and relative humidity) of drying medium (Kaya *et al.,* 2007). In order to improve the drying process, it is important to develop models to simulate the drying curves under different conditions. Drying as a method of food preservation causes many physical, chemical and biochemical changes which also depends on the pre treatment. Pre treatment quite often proceeds with drying of fruits and vegetable in order to minimize the adverse changes occurring during dehydration and subsequent storage. Pretreatment stops the metabolism of cut tissue either by killing cells or by injuring enzymatic route (Lewicki, 2006). Many researchers are looking for novel anti-browning agents to replace sulphites, among them citric acid and ascorbic acid are effective agents for the enzymatic browning control in apple slices (Zou *et al.,* 2008). Colour of the fruit products has a significant impact on consumers choice since the colour is one of the most vital quality attributes in food products. Enzymatic browning in fruits is a complex process, catalyzed by polyphenol oxidase (PPO) resulting in the formation of o-diphenols (slightly coloured) and oxidation of o-phenols to o-diquinomes followed by non- enzymatic formation of melanins (Brecht, 1995).

The control of enzymatic browning is frequently achieved through the use of different types of anti-browning agents. The use of chemicals that lower the product pH, finds a wide spread application in the control of enzymatic browning. The most commonly used acidulant is citric acid (Pizzacaro *et al.,* 1993; Santerre *et al.,* 1988). Reactants are irreversively oxidized during the reaction, which means that the protection is temporary since they are consumed in the reaction. Also due to the effect of pH, temperature, enzyme activity, oxygen and substrate concentrations and so on, the effect of ascorbic acid on browning is temporary (Santerre *et al.,* 1988). Although, there are many reports about use of different chemicals on the quality of fresh and dehydrated apple slices/cubes, there is limited information on the effect of anti-browning agents like citric acid, ascorbic acid and size/thickness of slices on maintenance of quality and colour parameters of dehydrated apple slices during drying and storage.

The main objective of the present study was to investigate the effect of citric acid, ascorbic acid, their combination and size of the slices on drying, colour and quality of the apple slices.

Materials and methods

Experimental site and raw material: Apples of Red Chief variety were obtained from experimental orchard of CITH, Srinagar, India and stored at 4 °C and RH 90%. After stabilization at the ambient temperature (20 °C) apples were initially washed with chlorinated water (100 ppm sodium hypochlorite) for 30 seconds to prevent surface contamination. Apples were randomly selected for each treatment/experiment.

Methodology and observations recorded: After peeling and coring, apples were cut in to 2 mm and 3 mm thickness slices, having uniform diameter of 20 mm and then dipped in to different solutions of ascorbic acid and citric acid *i.e.* T1: 2mm slice + 1% citric acid, T2: 2mm slice + 1% ascorbic acid, T3: 2 mm slice +1% citric acid + 1% ascorbic acid, T4: 2mm slice (control), T5: 3mm slice + 1% citric acid, T6: 3mm slice + 1% ascorbic acid, T7: 3 mm slice +1% citric acid + 1% ascorbic acid, T8: 3mm slice (control) for 2 minutes. Ascorbic acid and citric acid used were of analytical grade. Excess moisture was removed manually using a paper towel. Samples without any treatment were treated as control.

Drying: Drying was performed in a cross flow cabinet dryer (Biogen Mini Cabinet Dryer, India) at 55 °C in trays. A balance was placed outside the dryer, continuously determining and displaying the sample weight. The apple samples were placed on the trays in to the cabinet dryer. Sample weight loss was recorded every one hour during the drying process using a digital balance (Citizen India). Digital thermometer and hygrometer were used for determining temperature and relative humidity of dryer during experimentation. Dehydration lasted until a moisture content of about 12-15% (wet basis) was achieved. The dried samples were kept in air tight glass jar until the beginning of rehydration experiment. The effect of anti browning agents and slice thickness of apple slices was determined on the basis of firmness of dried slices, TSS, total titratable acidity (TTA), ascorbic acid, colour of dried slices and rehydration characteristics.

Dry matter composition (DMC): Dry matter of the apple samples was determined by drying milled samples (~10g) for 24 hours at 105±0.5°C to constant mass. Analyses were done in triplicate to every category. The average dry matter content (wdb), expressed in per cent was calculated using the following equations

$$Wdb\ (\%) = (m_2/m_1) \times 100$$

Where, m_2- mass of the apple sample after drying
m_1- mass of the apple samples before drying (g)

Colour measurement: The colour value of fruit and dried apple was measured using hunter lab calorimeter (model no. 45/0, serial no.CEE 20285). The colour values were recorded twenty times with each dried apple sample. The parameters L* (brightness), a* (redness) and b* (yellowness), were used to study the colour changes. L* refers to the brightness of the samples and ranges from black =0 to white =100. Negative value of a* indicates green, while a* the positive one indicates purple red colour. Positive b*indicates yellow and negative blue colours. The total colour difference (ΔE) was calculated as follows;

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$
$$\Delta L = L^* - L^*_o$$
$$\Delta a = a^* - a^*_o$$
$$\Delta b = b^* - b^*_o$$

Where L^*_o, a^*_o, b^*_o are colour parameters of fresh apple samples. Fresh apple samples were used as reference from the reference material.

Rehydration ratio (RR): The rehydration character was used as a quality index of the dried product (Velic *et al.,* 2004). Approximately 3g (±0.01g) of dried samples were placed in a 250 mL laboratory glass (repeted twice for each sample), 150 mL distilled water was added and the glass was covered and heated to boil within 3 minutes. The content of the laboratory glass was then gently boiled for another 10 min under vacuum and weighed. The rehydration ratio was calculated as:

$$RR = W_r / W_d$$

Where:
W_r - drained weight (g) of the rehydrated sample
W_d - weight of the dry sample used for rehydration.

Moisture loss and quality attributes: Moisture loss was calculated in 60 min interval by a digital balance of 0.01 g accuracy. The drying was continued till there was no large variation in the moisture loss and a constant weight was obtained. Dehydrated slices of apple of different thickness were packed in 200 g polythene bags and sealed and stored in the dry cool chamber/place. The product was analyzed for colour, physio-chemical parameters *i.e.* firmness (FF Fruit Firm Tester Yashica) TSS, total titratable acidity and ascorbic acid was calculated using methodology given by (AOAC, 2000).

Statistical design and analysis of data: The experiment was laid out in a complete randomized design (CRD). The treatment means were compared using the least significant difference (LSD) value of $P \leq 0.5$. All analysis was conducted using procedures of the Statistical Analysis System (SAS, Institute Inc., Cary, NC, USA), (Panse and Sukhatme, 1985).

Results and discussions

Time taken for drying: The final moisture content of dehydrated apple slices of different size and pretreated varied from 12-15 % (d.b) (Table 1). Pretreatment of slices with anti-browning agents (ascorbic acid and citric acid) and their thickness significantly influenced the drying time. Apple slices of less thickness (2mm) irrespective of pre drying treatments took minimum time for drying. In all, the samples treated with citric and ascorbic acid alone or in combination (citric acid + ascorbic acid) significantly reduced the drying time. However, minimum time taken was recorded in case of 2 mm slice pre treated with 1% citric acid (300 minutes) (Table 1). Reduction in time taken for drying of apple slices with pre treatment application of citric acid as also reported by (Jokic *et al.,* 2009) and application of mango slices with KMS and blanching (Singh and Goyal, 2012).

Rehydration ratio (RR): Pretreatment of citric acid and ascorbic acid resulted in the higher rehydration as compared to control, however, it was maximum in 2 mm and 3 mm size slices treated with 1 % citric acid + 1% ascorbic acid (4.9 and 4.6, respectively)

Table 1. Effect of the anti-browning agents and thickness of slices on drying time (15% moisture content), rehydration ratio and dry matter content of apple slices var. Red Chief

	Treatments	Drying time (min.)	Rehydration ratio	Dry matter content (%)	Firmness (RI)
T1.	2 mm slice + (Citric acid 1%)	300	4.1	86	10.63
T2.	2 mm slice + (Ascorbic acid 1 %)	310	4.4	87	10.60
T3.	2 mm slice + (Citric acid 1 % + Ascorbic acid 1 %)	320	4.9	89	11.00
T4.	2 mm slice (Control)	350	3.3	70	8.06
T5.	3 mm slice + (Citric acid 1%)	320	4.0	89	9.2
T6.	3 mm slice + (Ascorbic acid 1%)	330	4.3	90	9.0
T7.	3mm slice + (Citric acid 1% + Ascorbic acid 1%)	350	4.6	92	9.9
T8.	3mm slice (Control)	380	3.1	83	6.2
	LSD (*P*=0.05)	1.7	0.5	1.7	0.5

(Table 1). However, no significant differences were observed in the rehydration ratio between the size of slices and treatment with citric acid and ascorbic acid when applied individually. Jokie *et al.* (2009) reported no significant difference in the rehydration ratio between pre treatments with ascorbic acid and h-cystein.

Dry matter contents (DMC): Significant ($P<0.5$) variation for DMC was observed between thickness of apple slices treated with anti-browning agents (citric acid and ascorbic acid) (Table 1). Maximum dry matter contents were recorded in 3 mm slices treated with combination of citric acid and ascorbic acid (92%) (Table 1). Influence of pre drying treatments on dry matter content of apple slices was also reported by Lewicki and Jakubczyk (2004) and Doymaz (2004).

Firmness: Firmness is considered as an important quality criteria for dehydrated products. The size of slice and anti-browning agents have significant effect on firmness of apple slices, however maximum firmness (11.0 RI) was recorded in 2 mm size when pre treated either with citric acid (1%) or ascorbic acid (1%) (Table 1). Similar results showing retention of firmness in jackfruit fresh cut products by pre drying treatment of citric acid and 4-hexyl resorcinol were also reported by Narindra *et al.* (2009) and Centreras *et al.* (2008) for apple and strawberry dehydrated products.

TSS, TTA and ascorbic acid: Thickness of slices and application of anti browning agents were significantly effective to retain quality characteristics. Maximum TSS (18.9° Brix) was recorded in 3 mm slice treated with citric acid and ascorbic acid, however 2 mm slice treated with citric acid and ascorbic acid were statistically at par (Table 2). TTA of the slices was recorded non significantly different with respect to size and anti browning agents. Anti browning agents were significantly effective to stabilize the ascorbic acid content, however, maximum (18.0 mg/100g) was recorded in 2 mm slices treated with citric acid and ascorbic acid which was statistically at par with 3 mm slice treated with citric acid and ascorbic acid . Similar results showing stability of TSS, ascorbic acid and TTA in dehydrated products of mango treated with KMS have been reported by Singh and Goyal (2012), for Jackfruit slices by Narindera *et al.* (2009) and for *aonla* slices by Gajanana *et al.* (2006).

Total colour change (TCC): The pretreatments with anti browning agents and thickness significantly affected the colour change (Fig. 1, 2). Minimum colour change was observed in case of 2 mm slice treated with ascorbic acid and citric acid (10.10) and 3 mm slices treated with 1% citric acid and ascorbic acid (12.12) compared to control where it was found maximum (55.0) in case of 2 mm size slices and 68.0 in case 3 mm thick slices. Jokie *et al.* (2009) have also reported minimum colour change in apples when treated with ascorbic acid and citric acid. Similarly Zuo *et al.* (2008) also reported that pre treatment of apple slices with ascorbic acid and citric acid was found effective in retaining colour and reduce browning of finished products.

The study revealed that apple slices of 2 mm thickness size and pre-drying treatment with 1% ascorbic acid + 1% citric acid (anti oxidants) took less time for dehydration with minimal changes in colour, firmness and quality and also retained maximum compositional attributes.

Table 2. Effect of anti browning agents and thickness of slices on quality parameters of dehydrated apple slices var. Red Chief

	Treatments	TSS (ºB)	Total titrable acidity (%)	Ascorbic acid (%)
T1.	2 mm slice + (Citric acid 1%)	16.3	0.24	15.00
T2.	2 mm slice + (Ascorbic acid 1 %)	17.5	0.24	15.00
T3.	2 mm slice + (Citric acid 1 % + Ascorbic acid 1 %)	18.7	0.25	18.00
T4.	2 mm slice (Control)	11.9	0.26	13.00
T5.	3 mm slice + (Citric acid 1%)	17.6	0.25	14.00
T6.	3 mm slice + (Ascorbic acid 1%)	16.2	0.25	16.50
T7.	3 mm slice + (Citric acid 1% + Ascorbic acid 1%)	18.9	0.26	17.80
T8.	3 mm slice (Control)	12.5	0.27	12.00
	LSD (*P*=0.05)	0.5	N.S.	0.52

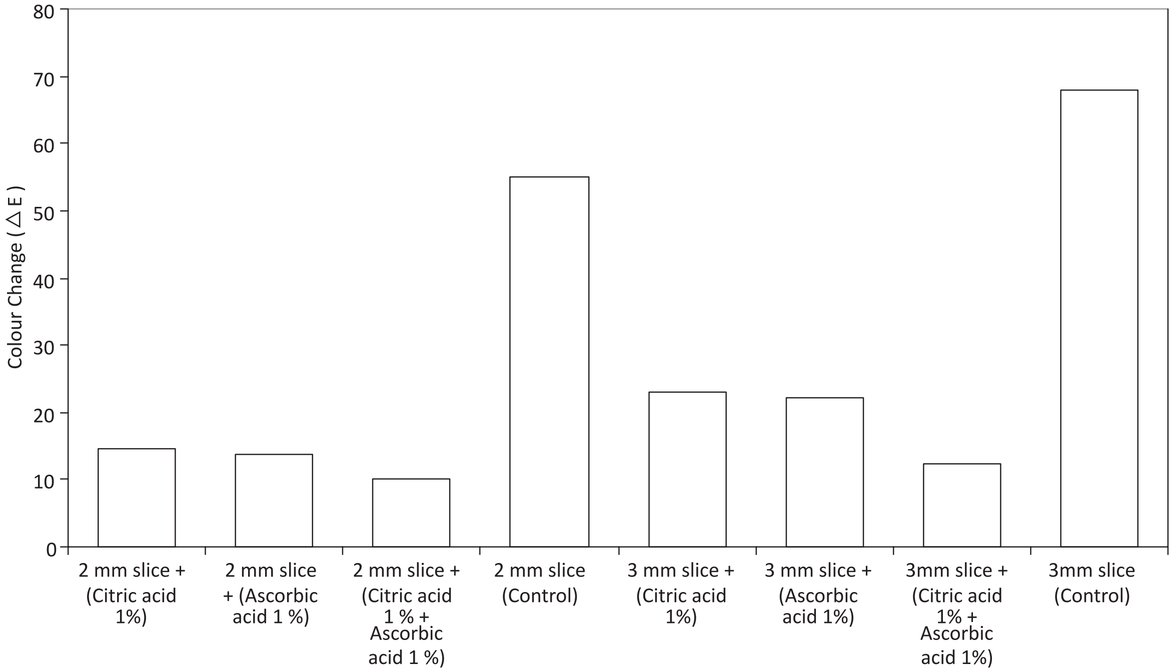

Fig 1. Effect of anti browning agents and thickness of slice on colour change in dehydrated apple slices

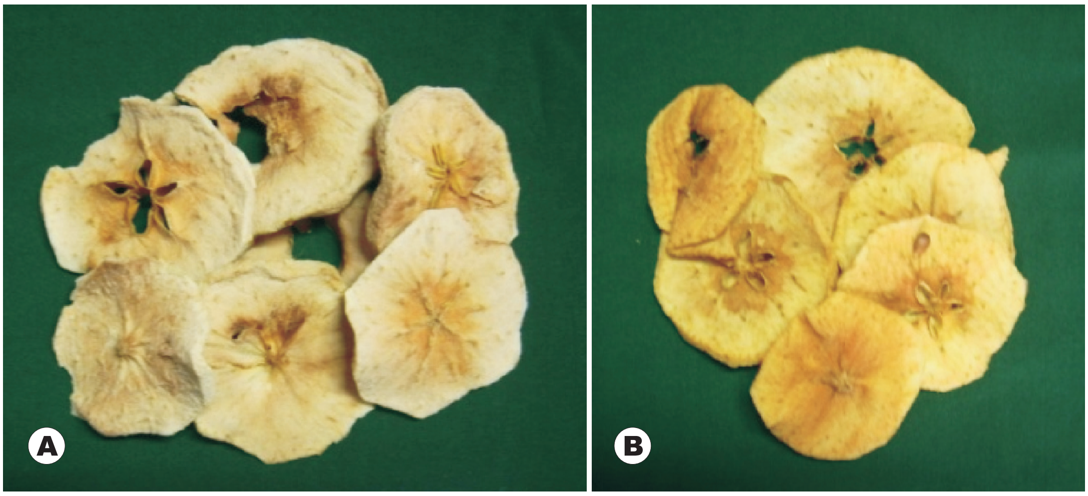

Fig. 2. A: 2 mm apple slices treated with citric acid (1%) and citric acid (1%). B: 2 mm apple slices (untreated)

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