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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 3 (2): 231-235, 2000

Dehydration Characteristics of Sweet Cherries *(Prunus avium* L.)

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Abstract: Effect of drying conditions on Allahidyen (Salihli) sweet cherries *(Prunus avium* L.) cultivated in Turkey was studied with the following treatments: dipping in 2 percent $Na_2S_2O_5$ for 7 minute, or in 0.5 per cent K_2CO_3 for one minute at 90°C before drying. The pretreatment were compared with untreated samples. The initial moisture contents of all the samples were 5.4528 gram H_2O/gram dry matter (g.H_2O/g.DM) while final moisture contents were 0.5254, 0.7796 and 0.6102 g.H_2O/g. DM for control, $Na_2S_2O_5$ and K_2CO_3 treated samples, respectively. The total soluble solids of dried samples were 66.9 for control, 63.3 and 60.3 per cent for $Na_2S_2O_5$ and K_2CO_3 treatments. A decline pattern in ascorbic acid concentration was noted. The anthocyanin extracts from salified samples showed increase in optical density as compare to control and the K_2CO_3 treated ones. The results indicated that there were no significant differences between the chemical and physical properties of the untreated (control) dried sweet cherries and those treated with $Na_2S_2O_5$ or K_2CO_3. Such conclusion enhanced the possibility of drying sweet cherries without any chemical treatments, a trend which will have a direct effect on human health by preventing the harmful effect of chemical additives and supporting the pattern of reaching "food safety".

Key words: Sweet cherries *(Prunus avium* L.), dehydration, anthocyanin, sensory evaluation

Introduction

In recent years, there is a question concerning the pretreatment and drying conditions that should be applied to vegetables or fruits to reach a higher nutrient quality and food safety. Sulfite treatment of fresh fruits (either by using soluble or gaseous treatments) is usually done before drying; but there is always doubt and uncertainty about the exact concentration of SO_2 that should be applied to prevent browning and to ensure a longer storage period of dried fruit. Reports of many investigators had suggested residue of less than 1000 ppm SO_2 in the fresh tissue, while others had mentioned higher concentrations (Abdelhaq and Labuza, 1987; Wijaya *et al.*, 1991).

Because of the short harvest season of fresh cherries and their sensitivity towards storage even at refrigerated conditions; most fresh cherries are preserved by any of the well known methods such as drying which is in common practices (Bolin *et al.*, 1981). Preservation of cherries by the drying method was considered to provide growers with a market for their products or to provide a nutrition and flvorful fruit for world-wide customers on a year-round basis (Torreggiani *et al.*, 1988).

Dried cherries offer many potential benefits to food and bakery processors specially from the cost view points. Supply is consistent and not affected by adverse weather conditions. No time is required for thawing as with frozen cherries or to open and dispose of cans for canned cherries. Dried cherries could be stored at room temperature for extended periods of time, and could b used as it is; in frozen products without becoming hard or unchewable and in products offering interesting textures to processed foods. They could be used also in producing innovative food products currently not available as a tasteful snack (Anonymous, 1993). The objective of the present study was to determine the effect of pretreatment and drying temperatures on quality of dried sweet cherries.

Materials and Methods

Fresh water cherries *(Prunus avium* L.) cultivated in Turkey were purchased from (Izmir) wholesale market in June-July, 1997.

Technological methods: Allandiyen sweet cherry variety (60 kg) was stored, washed by spraying with current of water and divided into three lots. The first lot was used as a control (no treatment) and the second one was dipped in 2 percent sodium meta bisulfite solution for 7 min. while the third lot was treated with 0.5 percent potassium carbonate for one min at 90°C.

Pits were removed with an automatic pitting machine and a single layer of pitted cherries was placed on stainless steel trays. Drying was carried out in a mixed air flow tunnel dryer with parallel-counter current flow at two stages (Fig. 1). The applied velocity was kept constant 112.5 m/minute having relative humidity as low as 10 percent at inlet.

Drying rate measurements: Drying rates were measured for different treated samples during drying. The sample weight was recorded every 50 minute till the end of the drying process. The moisture content at the beginning and at the end of the drying period was determined for samples using vacuum oven method at 70°C until reaching a constant weight (AOAC, 1984).

The general exponential equation: The following model described by Diamante and Munro (1991) was used to represent the drying rate curve of the material:

$$MR = \frac{M - M}{Mo - Me} \exp^{(-\alpha t)}$$

MR = Moisture ratio, dimension less
M = Moisture content (g H_2O/g DM)
Me = Equilibrium moisture content
Mo = Initial moisture content
α = Drying rate parameter min^{-1}
t = Time/min

This model assumes that the drying is a diffusion process and the resistance to diffusion lies on the surface of the material. The term a is the overall diffusion constant or the overall drying rate constat during the whole drying time. It was also used to characterize the drying process and was used for statistical comparison of the drying rate between the different samples.

Analytical methods: Moisture was determined by AOAC (1984) and total dry matter was determined by subtracting moisture percent

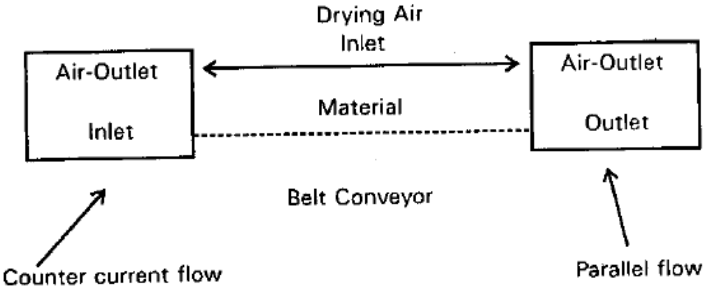

Fig. 1: Schematic flow diagram of the applied tunnel drier

from 100. Total soluble solids (T.S.S.) were measured by ATAGO, ATC-1 refractometer according to the AOAC (1984). In case of dehydrated samples, T.S.S. were measured after rehydration. The pH of fresh and homogenous rehydrated cherries was determined by using on Orino pH meter (model SA 520 USA). Total ascorbic acid was determined by photometric method at 520 mm as outlined by the AOAC (1984). Total sugar was determined by photometric method at 620 nm according to Giangiacomo *et al.* (1987). Texture of the fresh and rehydrated cherries was measured by using the penetrometer fruit tester FTO 11 and results were reported as (kg/cm^2) of firmness (Abou-Fadel and Miller, 1983).

Sulfite analysis: Total SO_2 (total sulfite was expressed as SO_2 equivalents) was analyzed by the modified method of Nordlee *et al.* (1985). Titration was performed with 0.01 N NaOH to improve the sensitivity of the method. Color values of the fresh and dried cherries were measured with Flexible Optic Tintometer Lovibond, England.

Anthocyanins: The anthocyanins were extracted as described by Gao and Mazza (1995) in which 30 grams of fresh sample or 6 grams of dried samples were homogenized in 50 ml of methyl/formic acid/water (70/2/28) solution in a Waring blender for 6 min. The homogenate was filtered through Whatman No. 1 filter paper. The optical density (0.0) of the filtrate was measured in the range of 360-640 nm with a spectrophotometer "Spectronic 20, Bauusch and Lomb, USA".

Rehydration and Sensory Evaluation: Five grams of dried samples were placed in 300 ml of boiling distilled water for (5, 30, 60, 180 and 360 min). After rehydration, samples were let for 3 min to separate the drained water and weighed as recommended by Stehli *et al.* (1988). Sensory evaluation of the rehydrated dried samples at 60, 180 and 360 min were carried out through a preference test (Dever *et al.*, 1996), by using a nine point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). In such a case, color, taste, flavor, texture and appearance were considered through 10 trained panelists.

Statistical analysis: The analysis of variance and Duncan's multiple range test were applied to determine statistically differences ($P<0.05$) of the measured parameters by using SAS program in the Computer Center at Ege University.

Results and Discussion

Drying curves: Drying curves were plotted using the data of moisture content expressed as (g.H_2O/g DM) versus drying time. Fig. 2 represents the effect of different tested pretreatment on drying rate, The initial moisture content of all the samples was 5.4528 g H_2O/g DM. The drying time for all experiments was 650 min; while the final moisture content varied from sample to another; being 0.5254, 0.7796 and 0.6102 g H_2O/g DM (Fig. 2) for the control, sulfur and potassium carbonate treated samples, respectively. It is evident from Fig. 2, that the constant drying rate period appeared clearly indicating the critical drying time to extend reaching 100 minute. The constant drying rate occurred when the moisture diffusion rate from the interior to the surface was greater than or equal to the rate of evaporation leaving the surface (Chiang and Petersen, 1987).

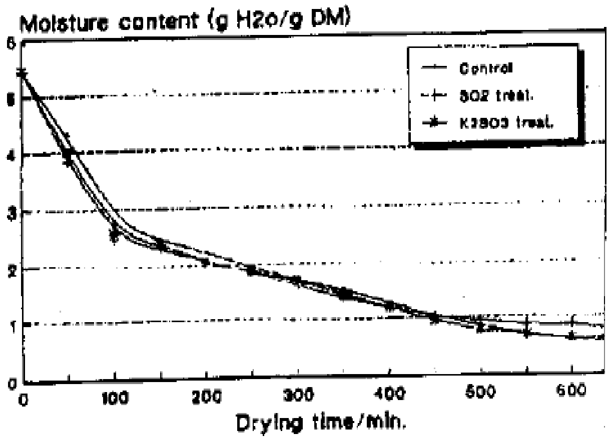

Fig. 2: Drying curves of the investigated cherry samples

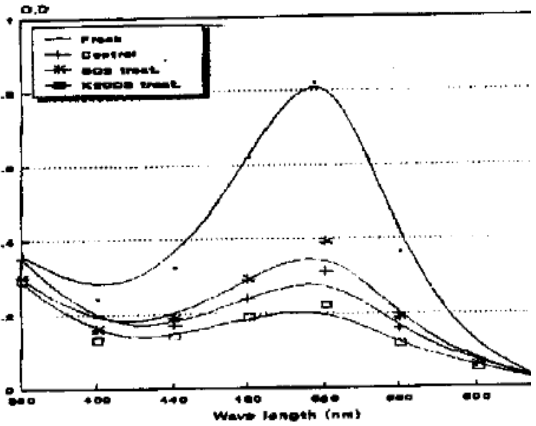

Fig. 3: Anthocyanin pigments in fresh and dried cherries

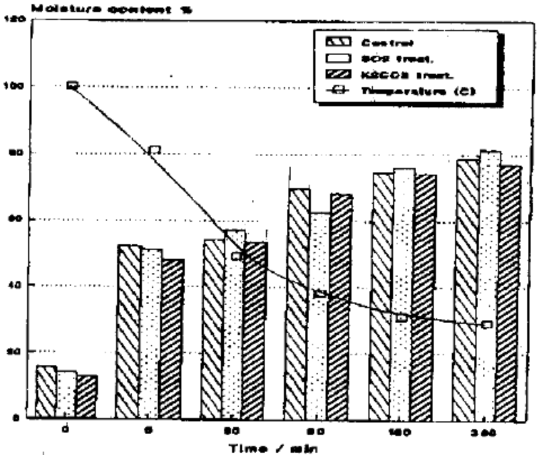

Fig. 4: Moisture content percentage vs. Rehydration time

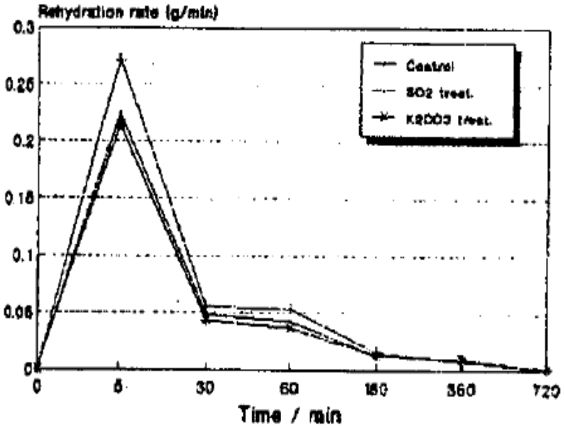

Fig. 5: Rehydration rate for dried cherry samples

The corresponding critical moisture contents of the control, sulfur and K_2CO_3 treated samples were 2.7290, 2.4758 and 2.5593 g H_2O/g DM: a trend which proved that the critical moisture of the sulfur treated sample was slightly less than the other samples. These results are in agreement with those reported by Abdelhaq and Labuza (1987) they mentioned that sulfating reduced the drying time by 10 to 20 percent. However, there were no significant differences in the moisture content particularly within the last stage of the drying process; i.e. from 150 min. to the end of drying period in all experiments.

The coefficient of determination (R^2) values for the exponential model were high indicating that the model represented the actual behaiour. On the other hand, the drying rate parameter of the control, sulfur and K_2CO_3 treated samples were 1.274×10^{-3}, 1.173×10^{-3} and 1.235×10^{-3} min^{-1}, respectively and the corresponding values of R^2 were 0.8296, 0.7514 and 0.8019. The relatively high R^2 values indicated the suitability of the diffusion model the suitability of the diffusion model to fit the drying data of the tested samples (Table 1). A similar behaviour has been observed by Shakya and Flink (1986) who termed the point at which the slope moisture content (Me) which was the changed as the "turning point", and referred this behaviour to the existence of a resistance to the mass transfer at the surface of the foodstuff.

Physicochemical composition

Total solids and Total Soluble Solids: Salihli fresh sweet cherry contained maximal total solids (15.52%) on complete ripening with a 14.90 percent of total soluble solids (Table 2). The total soluble solids contents of dried samples were 66.9 percent for the control, 63.3 and 60.3 percent for sulfite and K_2CO_3 treatments, respectively. Subsequently, the highest loss in soluble solids was noticed in samples treated by K_2CO_3; a pattern which could be related to the presence of cracks on the surface of this fruits.

pH and total sugars: The pH values of the fresh and dried sweet cherries ranged between 3.93 to 4.18 (Table 2) and a slight decrement was noticed in the dried samples. These results are in agreement with those of Drake *et al.* (1988), they found that the pH of Bing sweet cherry ranged from 3.56 to 3.74. A close relationship existed between the seasonal changes in percentages of total soluble solids and that of total sugars in relation to acidity. Table 2 shows that after drying the total sugar contents were approximately 16 percent as compared to 5.60 percent of the fresh samples.

Ascorbic acid: The ascorbic acid content of the tested fresh cherry sample was 0.425 mg/100 g and progressively decreased by drying (Table 2); the same trend was observed by Abou-Fadel and Miller (1983). A decline pattern in ascorbic acid concentration was noted in dried cherries mainly in control and 0.5 percent potassium carbonate treated samples than the cherries treated with 2 percent sodium metabisulfite. In other words, loss of ascorbic acid in the sulfite treated sample was less than in the control sample which might be due to protection of ascorbic acid from oxidation by sulfite during heat treatment. The results reported by Chandra and Nair (1993) support the present work of sulfur dioxide treatment since cherry halves those were dried without sulfuring lost 95 percent of their ascorbic acid during drying, compared to about 74 percent loss from the sulfured samples.

Texture: The texture of dried sweet cherries after rehydration was extremely firm (Table 2) due to the fact that some physiological breakdown of the tissues or skin may take place during the drying process. Chiang and Petersen (1987) arrived at the same conclusion.

Sulfite Analysis: Residual sulfite in dried fruits is important because of the recent health concerns for asthmatics symptoms. For the dried samples treated by sulfite; experimental results proved that more than 50 percent of the sulfite had been lost from the fruit

Table 1: Drying parameters of sweet cherries samples as calculated from the exponential equation

Tested samples	Drying time (min)	Drying rate parameter (α) (min^{-1})	Coefficient of determination (R^2)
Control (untreated)	650	1.274×10^{-3}	0.8296
Sample treated with 2% $Na_2S_2O_5$	650	1.173×10^{-3}	0.7514
Sample treated with 0.5% K_2CO_3	650	1.235×10^{-3}	0.8019

Table 2: Rhysico-chemical composition of Allandiyen (Salihli) cherries

Constituents (%)	Dried samples			
	Fresh	Control	$Na_2S_2O_5$ treat.	K_2CO_3 treat.
Total solids	15.52	84.27	85.49	86.96
Moisture = 100-T.S	84.48	15.73	14.51	13.04
T.S.S	14.90	66.90	63.30	60.30
pH	4.18	3.93	3.96	3.96
Ascorbic acid mg/100 g	0.425	0.225	0.288	0.165
Total sugar	5.60	16.20	16.90	16.40
Texture kg/cm^2	0.632	0.960	0.823	1.023

Table 3: Comparison of color scores of fresh and dried cherries

Color parameter	Fresh	Control	$Na_2S_2O_5$ treat.	K_2CO_3 treat.
Blue	15.25c	27.65b	38.90a	37.15a
Yellow	75.40a	42.10b	42.10b	35.43b
Red	54.90a	32.10b	44.60a	25.90b

Table 4: Sensory evaluation scores of dried sweet cherries after rehydration at 60, 180 and 360 minute

Tested samples	Color	Taste	Flavor	Texture	Appearance
			Rehydration 60 min		
Control	5.10	6.50	6.80	6.30	5.90
$Na_2S_2O_5$ treat.	7.00	6.60	6.90	6.50	6.50
K_2CO_3 treat.	5.30	6.80	6.80	6.00	5.60
			Rehydration 180 min		
Control	4.60	5.50	6.00	5.80	4.30
$Na_2S_2O_5$ treat.	4.60	5.40	5.50	6.30	4.00
K_2CO_3 treat.	5.50	4.90	5.80	5.90	4.50
			Rehydration 360 min		
Control	4.80	5.00	4.50	6.80	4.40
$Na_2S_2O_5$ treat.	4.40	4.80	4.70	5.90	4.00
K_2CO_3 treat.	4.50	4.80	4.90	6.50	3.90
Degree of significance	5.79a	6.63a	3.92a	3.67a	6.00a
Within rehydration	4.92b	5.25b	3.38b	3.38a	4.25b
Time.	4.54b	4.83c	2.75c	3.54a	4.08b

after drying (0.056 mg/kg). Such losses were slightly as a function of temperature; with more loss at the lower temperature as mentioned by (Abdelhaq and Labuza, 1987). This might be due to the conversion of sulfite to sulfate through an oxidative reaction which reduction the SO_2 volatility at higher temperatures. However, it is of importance to clarify that the acceptable daily intake (ADI) for sulfites as SO_2 is 0.7 mg/kg or 50 mg for a 70 kg individual, (Nordlee *et al.*, 1985).

Color: The Lovibond blue, yellow and red color values obtained for fresh and dried cherries sample are shown in Table 3. A significant decrement was found in yellow and red values for fresh sample compared to dried samples which could be related to the effect of temperature applied during drying. Darkening is caused (undoubtedly) from the non enzymatic Maillard-type browning reaction, which occurred between amino acid and sugars and results in production of dark colored compounds (Abdelhaq and Labuza, 1987). The color differences within or in between dried samples were also given in Table 3; where blue value for the control sample was significantly different than sulfite and K_2CO_3 treated samples. On the contrary, non significance was found between dried samples in yellow color, while values of red color proved that the sample treated by sulfite showed great differences with the other dried samples and being approximately very close to fresh sample.

Higher temperature, however, accelerated the rate of browning and other degradation or the enhancement of darkening of the red color of the dried samples could be referred to the degradation of anthocyanin. The sulfite treated samples were slightly superior by the untreated samples, so the former one was considered to be acceptable. Do *et al.* (1975) found a similar trend through freezing dehydrated compressed sour cherries.

Anthocyanin: The anthocyanin pigments are responsible for the attractive and appealing red color of the fresh cherries. The total anthocyanin content of the fresh sweet cherries was higher than that of the dried samples (Fig. 3) due to the degradation of pigments during drying. The retention of anthocyanin decreased the drying temperature increased (Do *et al.*, 1976). The absorption spectra of anthocyanin extracts from dried sulfited sample showed slight increase in optical density compared to untreated sample (control) or potassium carbonate samples as seen in Fig. 3. The degradation trend of anthocyanin pigments was noticed to be parallel with the ascorbic acid loss. These findings agree with those of Gao and Mazza (1995) who reported that the oxidation and ascorbic acid accelerated the degradation of anthocyanins and deteriorated such pigment into reddish brown substances. They also noticed that the browning reaction has been prevented effectively when ascorbic acid and sulfur dioxide are both available in the product.

Rehydration and Sensory Evaluation: The pre-dehydration treatment was designed to improve the rehydration properties of sweet cherries. Data showed in Fig. 4 indicated that sulfited samples absorbed more water than the control and than the samples treated by K_2CO_3 at different temperatures during the rehydration period. From the same data the highest rehydration rate of all the dried cherry samples was noticed after the first 5 min at 81°C (Fig. 5) but still not as much as the fresh sample. These findings agree with Do *et al*. (1975) they found that during rehydration of the freeze dried sour cherries, it reabsorbed only about one-fifth of the moisture content of the fresh fruits.

Sensory evaluation was carried-out with respect to color, taste, flavor texture and appearance of the rehydrated cherries fruit. The results given in Table 4 proved the presence of non significant differences among the different pre-drying treatments for all the characteristics examined, althopgh the coldr score of the sulfite treated sample was higher than the other treatments. These findings are matching with the observation of Nordlee *et al*. (1985). They found that dried cherries with high residual sulfite content will bleach the artificial colorant that was added to the cherries to give bright red color.

On the other hand, analysis of variance showed differences among the rehydration periods. For instance on using 180 and 360 min for the rehydration time, the available data indicated a decline in the overall quality characteristics of the tested samples than the rehydrated samples at 60 min as shown in Table 4. From these aforementioned results, it could be concluded that rehydration time for 60 min is enough for a reasonable rehydration of dried cherries, since on significant differences between treated samples and the control could be found.

The available data proved the success of providing dried sweet cherries of high quality. Subsequently, it is recommended to dry sweet cherries with the possibility of using in food products. The results also indicated that there is no significant difference between the chemical and physical properties of the untreated (control) dried sweet cherries and that of the sample treated by 2 percent sodium metabisulfite or 0.5 percent potassium carbonate. A result which stress upon the possibility of drying of sweet cherries without any additional chemical treatments. Such trend will certainly prevent the harmful effect of chemical additives on human health.

Acknowledgement

We would like to thank Prof. Dr. Uygun Aksoy; Department of Horticulture, Faculty of Agriculture, Ege University, Izmir, Turkey, for her continuous support and scientific contribution that made this study possible in Turkey.

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