RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 6 | Issue 2 | October, 2013 | 509–513

Effect of drying conditions on ascorbic acid content of spinach

P.S. TIWARI AND **SAMSHER**

Received : 27.09.2013; **Revised :** 22.10.2013; **Accepted :** 23.11.2013

See end of the Paper for authors' affiliation

Correspondence to :

P.S. TIWARI
Krishi Vigyan Kendra (SVBP. Univ. of Agric. and Tech.), PILIBHIT (U.P.) INDIA

■ **ABSTRACT :** Fresh spinach were dehydrated in mechanical tray dryer and open sun drying after pretreatment by (i) Dipping in solution containing 0.1% magnesium chloride, 0.1% sodium bicarbonate and 2% potassium metabisulphite in distilled water for 15 min. at room temperature (ii) Blanching in boiling water for 2 min (iii) Blanching in boiling water containing 0.5% sodium metabisulphite for 2 min. The ratio of spinach to pretreatment mixture was maintained at 1:5 (w/w). Pretreated spinach samples were dehydrated in mechanical tray dryer at 40, 50, 60 and 70^{0}C temperatures and in open sun drying with loading density 2.0, 2.5 and 3.0 kg/m^2. It was found that maximum ascorbic acid content (36.893 mg/100g) was in chemical treated sample dried at 40 ^{0}C temperature and 3.0 kg/m^2 loading density whereas minimum (25.591mg/g tissue) was obtained in blanched sample dried at 70 ^{0}C and 2.0 kg/m^2 loading density in tray dryer. However, in case of open sun drying, the maximum (16.637 mg/g tissue) and minimum (11.775 mg/g tissue) was obtained in chemical treated and 3.0 kg loading density and blanched sample and 2.0 kg loading density, respectively, The loss in ascorbic acid content when compared with fresh sample was found in the range of 50.295% to 65.522% which indicates more losses at higher drying temperatures. The maximum value corresponds to the processing condition of temperature 50 ^{0}C, chemical treated sample at 2.5 kg/m^2 loading density having a score of 9.0, while corresponding conditions for minimum score were for 70 ^{0}C and blanched at 3.0 kg/m^2 loading density. It was observed that at lower temperature colour was acceptable.Further, best three samples were chosen from sensory evaluation for 180 days storage period.The total loss of ascorbic acid during storage were found as 65.195%, 60.719% and 64.701% in 50 ^{0}C, 2.5 kg/m^2 loading density, chemical treated, 40 ^{0}C, 3.0 kg/m^2 loading, density chemical treated and 60 ^{0}C, 2.0 kg/m^2 loading density, chemical treated samples, respectively.The product quality on the basis of sensory evaluation and storage were found to be most acceptable when spinach were treated with solution of 0.1% $MgCl_2$ + 0.1% $NaHCO_3$ + 2% KMS, with dried at 50 ^{0}C and 2.5 kg/m^2 loading density.

■ **KEY WORDS :** Blanching, Loading density, Tray dryer, Open sun, Rehydration ratio, Coefficient of rehydration, Moisture contents

■ **HOW TO CITE THIS PAPER :** Tiwari, P.S. and Samsher (2013). Effect of drying conditions on ascorbic acid content of spinach. *Internat. J. Agric. Engg.*, **6**(2) : 509-513.

The fresh spinach is more commonly used after cooking because of its perishable nature. The most commonly used leafy vegetables are green and red amaranth, spinach(palak), chakota, fenugreek leaves, coriander leaves, kachi leaves, pudina, drumstick and curry leaves, which contribute to flavour, green colour, minor nutrients as well as medicinal properties. The conventional cooking of these vegetables results in the losses of water soluble vitamins and minerals and change in colour. However, the changes that occur during processing of leafy vegetables with regard to vitamins and colour are less understood. Secondly because of perishable nature, leafy vegetables are more commonly used immediately after harvest .The leafy vegetables are seasonal and available in plenty at a particular area bringing complexity in its post harvest processing. In peak season, prices fall steeply. The producer have to sell at throw away prices, delay leads to sharp fall in market prices, enormous deterioration in quality as well as quantity of vegetables. There are many methods of preservation of foods**.** Among these, the techniques of drying is well accepted and probably the oldest method of food preservation practiced by the mankind**.** It is relatively economical method, as concentration of solids become high, water activity reduces greatly, and product becomes chemically stable and free from insect-pest attack and mould- yeast growth during storage. Drying has been practiced at domestic level by utilizing solar energy. Long drying time, variation in weather and exposer to direct sun light leads to poor quality of the end product. Tray dryers

operated by electrical energy, solar energy and gasifires are commonly used for dehydration of vegetables, Mandhyan *et al*. (1988). The study was conducted to see the effect of drying temperatures, loading densities and pretreatment on ascorbic acid content of spinach. Sensory evaluation of rehydrated sample was conducted.

METHODOLOGY

Preparation of samples :

The fresh spinach was washed thoroughly in tap water so as to remove roots and stem. Leaves and soft stem were separated from the rest parts. Care was taken to avoid bruised and discoloured leaves. Pre-treatments were given by three methods (i) Dipping in solution containing 0.1% magnesium chloride, 0.1% sodium bicarbonate and 2% potassium metabisulphite in distilled water for 15 min. at room temperature (ii) Blanching in boiling water for 2 min (iii) Blanching in boiling water containing 0.5% sodium metabisulphite for 2 min. The ratio of spinach to pre-treatment mixture was maintained at 1:5 (w/w).

Drying of spinach :

After pretreatments, the spinach were loaded in perforated stainless steel trays at the rate of 2.0, 2.5 and 3.0 kg/m^2 tray area and dried at 40, 50, 60 and 70^{0}C temperature in tray dryer with constant air velocity of 2.0 m/s. The open sun drying was also carried out during the day time (temp: 37-45^{0}C, RH: 25-37%). The untreated samples of spinach were dried as control samples. Spinach was dried from 91% ± 1 per cent moisture content to about 5±1 moisture content (wb).

Ascorbic acid content :

The ascorbic acid content was estimated by 2, 6 – dichlorophenol indophenol dye visual titration method (Ranganna, 1986). The dye is blue in alkaline solution and red in acid solution. The dye colour is reduced by ascorbic acid to a colourless form.

Standardization of dye :

5 ml of HPO_3 was added to 5 ml standard ascorbic acid. Micro burette was filled with dye and titrated with dye solution to pink colour which persist at least 15 sec. Dye factor *i.e.* mg of ascorbic acid per ml of the dye was calculated using the following formula :

$$\text{Dye factor} = 0.5/\text{titre}$$

Sample preparation and procedure :

Sample of 2 g blended with 3% HPO_3 and volume was made to 20 ml with HPO_3 and filtered. An aliquot (2 ml) of the HPO_3 extract of sample was taken and titrated against the standard dye to a pink colour end point which persist for at least 15 sec. Titration was rapidly carried out and a preliminary determination was made of the titer. The experiment was repeated for getting accurate results.

Calculations :

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value x Dye factor x Vol. made up x 100}}{\text{Extract taken for estimation x Wt. of sample taken}}$$

RESULTS AND DISCUSSION

Ascorbic acid (vitamin C) content of dried spinach is presented in Table 1. It shows that ascorbic acid content of tray dried samples varied from 27.229 to 35.096 mg/100g in case of untreated samples, 25.591 to 33.518 mg/100g in case of blanched samples, 26.095 to 34.124 mg/100g in case of chemically blanched samples and 28.074 to 36.893 mg/100g in case of chemical treated samples. In case of sun dried samples, the values of ascorbic acid were found as 13.215 to 15.709 mg/100g (untreated), 11.775 to 13.816 mg/100g (blanched), 12.398 to 14.169 mg/100g (chemically blanched) and 14.256 to 16.637 mg/100g (chemical treated) samples. The ascorbic acid content of fresh sample was 74.0 mg/100g. The loss of ascorbic acid was very high and ranged from 50.295 % (chemical treated, 3.0 kg/m^2 and 40^{0}C temperature) to 65.522 % (blanched, 2.0 kg/m^2 and 70 ^{0}C). The loss of ascorbic acid was higher when spinach was dried at higher temperature. This might be because of the increased activity of ascorbic acid oxidizing enzymes due to heating, which leads to destruction of ascorbic acid and leaching of vitamin C in washing water. It was also observed that although at higher temperature in tray dryer, the loss of ascorbic acid was less as the drying time was shorter Lakshmi and Vimala (2000) reported that losses of ascorbic acid content from green leafy vegetables ranged from 69 to 85% due to sun drying (35 to 40^{0}C) and 51 to 63% due to cabinet drying (60 to 70^{0}C). The extent of loss depends on the method of processing. Higher rate of water removal is safe to minimize the losses of ascorbic acid. This may be the reason of loss of ascorbic acid which was lesser during cabinet drying as compared to sun drying. The other reason for losses of ascorbic acid may be due to the proportion of moisture content and dry matter in the finished product which might have affected the ascorbic acid in different drying conditions. In some cases, the loss of ascorbic acid was at par which might be due to cumulative effect of temperature, exposed time for drying, loading density and treatment conditions. Overall, maximum loss of ascorbic acid was observed in open sun drying and least in tray dryer at 40^{0}C temperature.

Sensory evaluation :

Sensory evaluation of rehydrated sample was conducted

Table 1 : Experimental data on ascorbic acid content of dried spinach samples

Drying temp. (^{0}C)	Loading density	Treatment (kg/m^2)	Ascorbic acid content (mg/100g of tissue)	Per cent loss in ascorbic acid
40	2.0	CT	34.650	53.317
		BC	31.914	57.003
		B	32.021	56.859
		UT	33.612	54.715
	2.5	CT	35.190	52.589
		BC	34.124	54.026
		B	33.518	54.842
		UT	35.096	52.716
	3.0	CT	36.893	50.295
		BC	33.597	54.736
		B	32.901	55.673
		UT	34.337	53.739
50	2.0	CT	31.930	56.982
		BC	29.781	59.877
		B	29.267	60.569
		UT	31.295	57.837
	2.5	CT	32.746	55.882
		BC	30.737	58.589
		B	30.377	59.074
		UT	30.019	59.556
	3.0	CT	33.019	55.514
		BC	31.646	57.364
		B	31.003	58.230
		UT	32.878	55.704
60	2.0	CT	30.655	58.699
		BC	28.833	61.154
		B	28.254	61.934
		UT	29.692	59.997
	2.5	CT	31.211	57.950
		BC	29.464	60.304
		B	29.124	60.762
		UT	30.907	58.360
	3.0	CT	32.277	56.514
		BC	30.610	58.760
		B	30.157	59.370
		UT	31.299	57.832
70	2.0	CT	28.074	62.177
		BC	26.095	64.843
		B	25.591	65.522
		UT	27.229	63.315
	2.5	CT	29.913	59.699
		BC	27.875	62.445
		B	27.278	63.249
		UT	28.082	62.166
	3.0	CT	30.751	58.570
		BC	28.526	61.568
		B	28.378	61.767
		UT	29.082	60.819
	2.0	CT	14.256	80.793
OSD		BC	12.398	83.297
		B	11.775	84.136
		UT	13.215	82.196
	2.5	CT	15.138	79.605
		BC	13.044	82.426
		B	12.901	82.619
		UT	14.376	80.632
	3.0	CT	16.637	77.585
		BC	14.169	80.910
		B	13.816	81.386
		UT	15.709	78.836

using method of 9 – point hedonic scale and the mean scores obtained from different panelists were calculated. The results for all the parameters *viz*., colour, appearance, taste, flavour and overall acceptability were calculated for sensory attributes.

Overall acceptability :

The mean scores, the overall acceptability varied from 5.5 to 9.0. The maximum value corresponds to the processing condition of temperature 50^0 C, chemical treated sample at 2.5 kg/m^2 loading density having a score of 9.0, while corresponding conditions for minimum score were for 70^0 C and blanched at 3.0 kg/m^2 loading density. It was observed that at lower temperature colour was acceptable. As temperature increased colour declined but flavour and appearance was good at 50 ^{0}C and after that it was decreased. Hence, the overall quality of dried spinach was good at 50^0 C for chemical treated sample at 2.5 kg/m^2 loading density.

Further, best three samples were chosen from sensory evaluation and storage of those samples were carried out for a period of 180 days. Based on the overall acceptability, the three best samples with highest score were

S_1: 50^0 C, 2.5 kg/m^2 loading density, chemical treated sample

S_2: 40^0 C, 3.0 kg/m^2 loading density, chemical treated sample

S_3: 60^0 C, 2.0 kg/m^2 loading density, chemical treated sample

Effect of storage time on ascorbic acid content :

The data on ascorbic acid content (mg/100g) at 0, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150 and 180 days of storage are shown in Table 2 and Fig. 1. It was observed that the loss of ascorbic acid content varied from 32.746 mg/100g (0 day) to 25.755 mg/100g (180 days), 36.893 mg/100g (0 day) to 29.068 mg/100g (180 days) and 30.655 mg/100g (0 day) to 26.121 mg/100g (180 days) in S_1, S_2 and S_3 samples, respectively. The total ascorbic acid reduction (%) after 180 days period was calculated as 65.195%, 60.719% and 64.701% for S_1, S_2 and S_3 samples, respectively. The higher loss of ascorbic acid during storage may be attributed to sensitivity of vitamin C at high temperature with prolong storage.

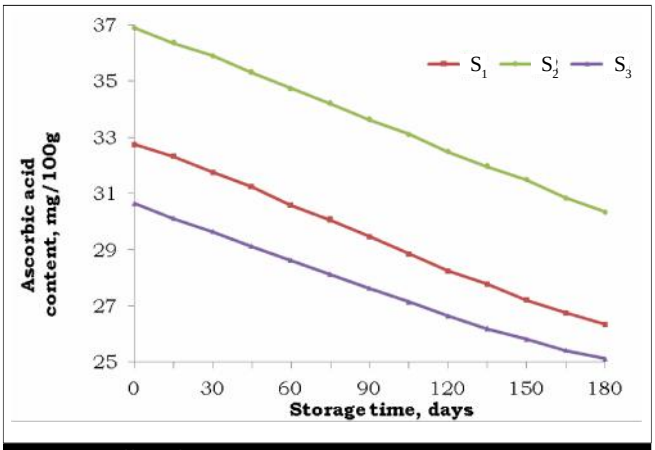

Fig. 1 : Effect of storage (days) on ascorbic acid content

Changes in sensory qualities of spinach during storag:

The data on sensory parameters revealed that as storage period advanced, there was decrease in sensory quality parameters of dried spinach. The rate of decrease in quality was less in all the three samples and however, it was slightly more in S_3 as compared to S_1 and S_2 samples. The least decrease in overall acceptability was noticed in S1 sample. After 180 days of storage, the S_1 and S_2 samples retained the

Table 2 : Ascorbic acid content of dried spinach in room temperature storage

Storage time (days)	Ascorbic acid , mg/100 g tissue at different days		
	S_1	S_2	S_3
0	32.746	36.893	30.655
15	32.324	36.348	30.414
30	31.967	35.895	29.749
45	31.595	35.297	29.449
60	29.958	34.741	28.942
75	29.248	34.197	28.489
90	28.517	33.615	27.959
105	27879	33.114	27.514
120	27.124	32.489	27.285
135	26.598	31.958	26.889
150	26.354	31.497	26.588
165	25.987	29.846	26.326
180	25.755	29.068	26.121

highest sensory score in case of colour which were awarded 9.0 and 8.0, respectively, while the sensory score of 7.0 was given to S_3 sample. In all the samples, the higher sensory scores for colour, appearance, taste, flavour and overall acceptability indicated their better suitability for dehydrated spinach after 180 days of storage. Slight differences in sensory characteristics were observed for selected samples after 180 days of storage. The best consumer preference in terms of overall acceptability after 180 days of storage was found in sample S_1 (8.25) followed by S_2 (7.75) and S_3 (7.50). Hence, S_1 sample was found better on the basis of maximum score obtained for colour, appearance, taste and overall acceptability.

Conclusion:

– Loss of ascorbic acid increased with increase in drying air temperature and decreased with increase in loading density for both tray and open sun drying. However, loss was observed maximum in open sun drying.

– The total loss of ascorbic acid during storage were found as 65.195%, 60.719% and 64.701% in S1 (50 ^{0}C, 2.5 kg/m^2 loading density, chemical treated), S2 (40 ^{0}C, 3.0 kg/m^2 loading, density chemical treated) and S3 (60 ^{0}C, 2.0 kg/m^2 loading density, chemical treated) samples, respectively.

– The product quality on the basis of sensory evaluation and storage were found to be most acceptable when spinach were treated with solution of 0.1% $MgCl_2$ + 0.1% $NaHCO_3$ + 2% KMS, with dried at 50 ^{0}C and 2.5 kg/m^2 loading density.

Authors' affiliations:

SAMSHER, Department of Agricultural Engineering and Food Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, MEERUT (U.P.) INDIA

REFERENCES

Ahmed, J. and Shivhare, U.S. (2001). Effect of pre-treatment on drying characteristics and colour of dehydrated green chillis. *J. Food Sci. & Technol.,* **38**(5) : 504-506.

Ahmed, J., Shivare, U.S. and Singh, G. (2001). Drying characteristics and product quality of coriander leaves. *J. Food Bioproducts Processing,* **79** (2) : 103-106.

Lakshmi, B. and Vimala, V. (2000). Nutritive value of dehydration green leafy vegetable powder. *J. Food Sci. & Technol.,* **37**(5) : 465-471.

Mandhyan, B.L., Aboroal, C.M. and Tyagi, H.R. (1988). Dehydration characteristics of winter vegetables. *J. Food Sci. & Technol*., **25**(1): 20 - 22.

Ranganna, S. (1986). *Hand book of analysis and quality control for fruits and vegetable products*. Tata McGraw-Hill Publishing Ltd. New Delhi. 1112 p.