A Research Note

Misting Effects on Ascorbic Acid Retention in Broccoli During Cabinet Display

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ABSTRACT

Total ascorbic acid (TAA) was determined in misted and nonmisted broccoli during display cabinet storage (18 ± 2°C) for 0, 6, 24, 48 and 72 hr. TAA was calculated on dry weight basis to account for moisture differences. Moisture was significantly greater in misted versus nonmisted samples ($p = .0008$). Misting significantly promoted the retention of TAA compared with nonmisted samples over 72 hr ($p = .0019$). The rate of ascorbic acid degradation in misted and nonmisted samples followed first order kinetics.

INTRODUCTION

VEGETABLES are an important contributor of ascorbic acid to the human diet. Previous research demonstrated ascorbic acid retention in vegetables was influenced by many factors, such as moisture, water activity, processing, temperature, pH, packaging, modified and controlled atmospheres, as well as environmental conditions after harvest, until purchase and/or use by consumers (Zepplin and Elvehjem, 1944; Ezell and Wilcox, 1959; Burgheimer et al., 1967; Lee and Labuza, 1975; Addo, 1981; Klein and Perry, 1982; Sumner et al., 1983; Bushway et al., 1985; Kailasapathy and Koneshan, 1986; Weichmann, 1986; Klein, 1987; Barmore, 1987).

Ezell and Wilcox (1959) demonstrated low temperature and maintenance of tissue turgidity at 100% humidity delayed degradation of ascorbic acid in fresh vegetables. Addo (1981), studying effects of storage and dehydration on total ascorbic acid retention of ten Nigerian vegetables, demonstrated ascorbic acid retention was adversely affected by increasing storage time.

Automatic misting is a new humidification technology developed in the last decade to prevent dehydration, extend shelf-life and improve appearance of produce in retail display cases. Automatic misting systems are installed in some retail produce display cabinets and designed to automatically spray the produce with a fine mist of water at controlled time intervals. This procedure is increasingly accepted in the nationwide retail produce industry (Morr, 1988). However, effects of misting on nutrient retention and produce quality have not been assessed. Although many studies reported nutrient composition of produce held at varying humidities, these reports are for nutrient composition of only nonmisted produce (Klein and Perry, 1982; Haytowitz and Matthews, 1984; Hudson et al., 1985; Russell, 1986; Kailasapathy and Koneshan, 1986).

The objective of our study was to determine the effect of misting on total ascorbic acid retention in broccoli during display cabinet storage (18 ± 2°C) for up to 72 hr.

MATERIALS & METHODS

Broccoli

Broccoli (Green Duke cultivar) was obtained from a local wholesale distributor in Urbana, IL in July, 1989. The broccoli was harvested in Salinas, CA, three days before delivery. After harvesting, the broccoli was hydrocooled and packed in ice for shipping.

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Experimental design

Upon delivery, random assignment of 22 broccoli bunches was made to the misted and nonmisted sections of a refrigerated produce display cabinet (Corrigan Misting System, Northbrook, IL). Misting intervals were 4 sec every 4 min, providing a total of 43.5 mL water per 4 min. After each misting interval, the water drained back into a holding tank for reuse. Broccoli samples were stored in the display cabinet over a 72 hr sampling period. Room temperature was 25 ± 4°C, while the cabinet was maintained at 18 ± 2°C. However, the temperature of the misted section of the case was 2-4°C lower than the nonmisted section due to effects of misting. The room was equipped with fluorescent lights, kept on 8 hr and off 16 hr each day.

Sampling procedure

At each time interval (0, 6, 24, 48, and 72 hr) samples taken were: (1) a composite of one floret with 2 in. of stem from the right side of each broccoli bunch, and (2) 200 mL of misting water drained from the cabinet. After each broccoli bunch was sampled it was rotated one quarter turn.

Misted samples were blotted dry with a cloth towel. Both misted and nonmisted samples were ground at speed control #2 in a Kitchen-Aid K-5A grinder (Hobart Manufacturing, Troy, OH). Twenty-five grams of ground broccoli or 50 mL drain water were analyzed for total ascorbic acid and moisture was determined on 5g ground broccoli tissue.

Moisture content

About 5g ground broccoli were used for each duplicate moisture determination for misted and nonmisted samples (AOAC, 1980). Percent solids was calculated and used to determine TAA on a dry weight basis.

Total ascorbic acid determination

Total ascorbic acid (TAA) in broccoli (25g) was determined by a microfluorometric assay (Deutsch and Weeks, 1965). Drain water samples were analyzed by combining 50 mL drain water with 6% metaphosphoric acid made up to 100 mL volume. This volume was combined with 2g acid-washed Norit in a 250 mL Erlenmeyer flask prepared following the same procedure as for the broccoli samples. Triplicate readings were performed. TAA content was calculated on both a wet and dry weight basis for misted and nonmisted broccoli samples. Percent TAA retention was determined on a dry weight basis. TAA was calculated for water samples at each sampling interval.

Statistical analysis

Three replications of our study were performed. Significance was determined by a two-way analysis of variance (ANOVA), with sources of variance being misted, nonmisted and storage time.

RESULTS & DISCUSSION

Moisture content

The moisture content of the broccoli samples over 72 hr display cabinet storage is given in Table 1. A significant dif-

Table 1—Mean percent moisture, total ascorbic acid (TAA) (calculated on wet and dry bases) and percent TAA retention in misted (M) and nonmisted (NM) broccoli samples held 72 hr in display cabinet storage[a]

Storage interval (hr)	Percent moisture content		TAA Content				Percent TAA retention (dry wt)	
			Wet wt (mg/100g)		Dry wt (mg/100g)			
	M	NM	M	NM	M	NM	M	NM
0	89.1 ± 1.71		97.8 ± 8.55		902.0 ± 77.27		100%	
6	88.9 ± 1.61	88.5 ± 1.65	100.7 ± 1.30	98.5 ± 1.40	924.6 ± 130.06	871.0 ± 120.78	102.1 ± 6.88	96.3 ± 6.44
24	89.1 ± 1.63	87.1 ± 1.20	90.2 ± 13.54	97.6 ± 6.65	819.6 ± 18.23	759.6 ± 65.59	89.7 ± 4.32	84.7 ± 3.37
48	89.1 ± 1.73	85.3 ± 1.55	79.4 ± 14.75	92.7 ± 16.30	769.3 ± 46.50	659.3 ± 80.50	81.6 ± 6.95	70.2 ± 10.40
72	89.3 ± 1.40	84.2 ± 0.75	71.4 ± 12.66	81.7 ± 4.83	669.3 ± 86.03	518.3 ± 44.66	74.2 ± 7.78	57.3 ± 2.62

[a] Values shown are means ± standard deviations.

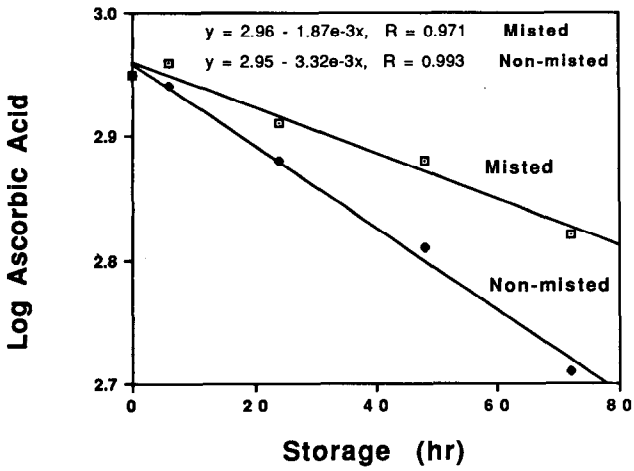

Fig. 1.—Log mean total ascorbic acid (dry weight basis) vs storage time (hr) in misted and nonmisted broccoli samples held 72 hr in display cabinet. Figure includes linear regression equations and correlation coefficients (R).

ference in moisture was found between misted and nonmisted samples ($p = 0.0008$). Moisture decreased in nonmisted samples due to dehydration, while moisture of misted samples remained close to original values. This confirms findings of Ezell and Wilcox (1959), that increased humidity at refrigerator temperatures helped retain moisture in vegetables. At 5–6% moisture loss, broccoli is considered unmarketable (Robinson et al., 1975). Nonmisted broccoli samples reached 5% moisture loss after 72 hr.

Water loss in nonmisted broccoli samples possibly was accelerated by the slightly higher temperature in the nonmisted side of the display case.

TAA retention

The mean TAA of broccoli on a wet basis at time 0 was 97.8 mg/100g, slightly higher than values reported by Wills et al. (1983) of 87.9 mg/100g, and Haytowitz and Matthews (1984) of 93.2 mg/100g. This variation could be due to varietal differences, growing and post-harvest storage conditions. The TAA calculated on wet and dry weight bases are given in Table 1. The TAA calculated on a wet basis was greater in the nonmisted broccoli samples after 6 hr storage. However, calculation of the TAA on a wet basis does not account for moisture content differences between misted and nonmisted samples. To account for this difference, TAA content was calculated on a dry weight basis. As shown in Table 1, when TAA was calculated on a dry weight basis, the misted broccoli samples retained more ascorbic acid than the nonmisted samples at all times. Thus, when comparing TAA of misted and nonmisted samples it is critical to account for differences in moisture by expressing data on a dry weight basis. The TAA retention over 72 hr was significantly greater in misted versus nonmisted broccoli samples ($p = 0.0019$) as shown in Table 1. Percent ascorbic acid loss in nonmisted broccoli after 72 hr was 42.7%, similar to the percent loss reported by Zepplin and Elvehjem (1944), while losses were 25.8% in misted broccoli. Ascorbic acid degradation could have been accelerated by the slightly higher temperature in the nonmisted part of the display case. Additional research is needed to assess the temperature effect on ascorbic acid degradation.

The rate of ascorbic acid degradation in misted and nonmisted broccoli over 72 hr followed first order reaction kinetics as shown in Fig. 1. Linear regression equations and correlation coefficients are given in Fig. 1. The first order reaction rate constants, k, for the misted and nonmisted broccoli samples were 4.30×10^{-3}/hr and 7.64×10^{-3}/hr, respectively.

Storage time also significantly affected TAA retention ($p = 0.0001$). This is in agreement with the findings of Kailasapathy and Koneshan (1986), that vegetables incurred significant ascorbic acid losses with increased storage time. Ascorbic acid loss in broccoli was probably due to oxidation of L-ascorbic acid and dehydroascorbic acid to the biologically inactive form. Also, alteration of cellular integrity of broccoli due to dehydration could lead to increased degradation of ascorbic acid by plant oxidase enzymes.

No ascorbic acid was detected in the drain water at any storage interval. Apparently there was no leaching of ascorbic acid from the samples into the water from misting.

SUMMARY

OUR STUDY shows misting promoted total ascorbic acid and moisture retention in broccoli during 72 hr storage. To compare ascorbic acid retention in misted and nonmisted samples, the differences in moisture content were accounted for by calculating TAA values on a dry weight basis. The rate of ascorbic acid degradation in misted and nonmisted broccoli followed first order kinetics. Additional research is needed to determine the effect of misting on other important nutritional and quality parameters, such as enzyme content, vegetable color and texture.

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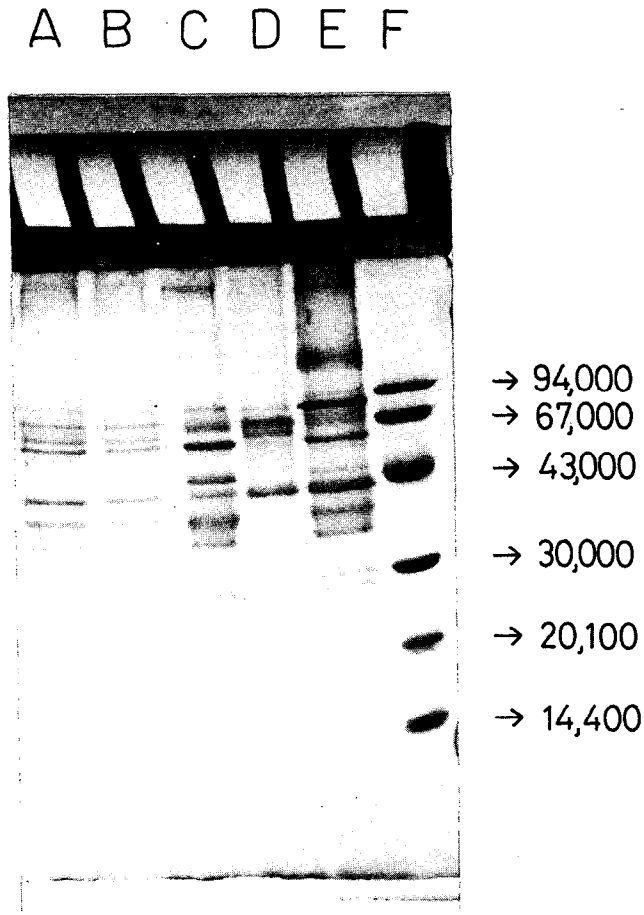

Fig. 2—5-20% SDS-polyacrylamide gel electrophoretic patterns of white film homogenates. Lanes A and B correspond to KI homogenates. 12.68 and 5.03 μg of protein were loaded, respectively. Lanes C, D and E correspond to urea homogenates. Loaded protein was 27.42, 12.47 and 16.45 μg, respectively. Lanes F corresponds to standards: phosphorylase b (94,000), albumin (67,000), ovalbumin (43,000), carbonic anhydrase (30,000), trypsin inhibitor (20,100) and α-lactalbumin (14,400).

presented only 11.7% of the total free amino acid content. Since the total FAA content represents 25% of the total protein it is rather questionable that tyrosine precipitation is the cause of film formation.

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