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The Stability of Vitamin C (L-Ascorbic Acid) in Bottled and Canned Orange Juice

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ABSTRACT

The stabilizing effect of two levels of cysteine and sodium metabisulphite on vitamin C (L-ascorbic acid) in bottled orange juice kept at room temperature was investigated. Although increasing the level of either chemical stabilizer from 200 to 400 ppm had a significant stabilizing effect ($p < 0{\cdot}05$), this did not prevent decline of ascorbic concentration with storage time. The descending order in effectiveness to stabilize vitamin C was 400 ppm cysteine, 200 ppm cysteine, 400 ppm sodium metabisulphite and 200 ppm sodium metabisulphite. The level of the vitamin in refrigerated canned juice without added stabilizer was, on the whole, higher than in bottled juice. Independent regression analysis on ascorbic acid level and storage time data indicated that ascorbic acid depletion with time was almost linear, with correlation coefficients greater than 0·890 for all cases. Their use for predicting the storage time for complete ascorbic acid depletion in orange juice is discussed.

INTRODUCTION

Fresh citrus fruit juice is a rich source of vitamin C. In order to facilitate juice preservation and distribution, it is a technological practice to package the juice in metal cans, glass bottles and plastic containers.

Glass containers, being cheap and often reusable, are a favourite type of package for juice produced in many developing countries, unlike cans which are expensive and demand sophisticated machinery for container closure (Heiss, 1970). A bottled fruit juice (or squash) kept under ambient temperature conditions for an extended period, especially in a tropical environment, is likely to lose all its vitamin C content if there are no added stabilizers (Cameron, 1978; Shah & Zafar, 1975). Assuming that the container is impermeable to oxygen, the principal causes for vitamin C destruction are oxidation by residual oxygen in the headspace (Gresswell, 1974) followed by anaerobic decomposition (Kefford *et al.*, 1959) and by the destructive influence of light, especially in juices packaged in transparent or clear bottles (Goussault *et al.*, 1978).

Metal chelating agents, especially those capable of scavenging copper and iron (e.g. ethylenediamine tetraacetic acid and diethylamine pentaacetic acid) have been shown to stabilize ascorbic acid in fruit juices (Timberlake, 1960). In addition to metal chelating agents, sorbates, benzoates, sulphites and metabisulphites may be added to juices as antimicrobial agents. The sulphites and metabisulphites, in addition to exerting antimicrobial activity, also have a stabilizing effect on vitamin C (El-Gindy & Shehata, 1974). Use of sodium metabisulphite (providing over 450 ppm SO_2 in citrus juices) has been reported (Zipper, 1974). Excessive levels of sulphites or metabisulphites in food products, especially those which are not given a desulphitation treatment prior to consumption, notably fruit juices, have a characteristic pungent smell due to residual sulphur dioxide. Reduction in level of SO_2-furnishing chemicals in fruit juices, without risk of spoilage and vitamin C depletion, is therefore worth investigating. Alternative vitamin C stabilizers, particularly those occurring naturally in foods, could serve as stabilizers for vitamin C. L-cysteine hydrochloride at a rate of up to 24 mg/100 ml of juice has a stabilizing effect on ascorbic acid (Timberlake, 1960) and prevents enzymatic browning in fruit juices (Walker & Reddish, 1964). As cysteine is not a commonly used vitamin C stabilizer, its relative effectiveness over sulphites needs to be explored.

This study was therefore undertaken to investigate the stabilizing effect of two levels of cysteine and sodium metabisulphite on vitamin C in bottled orange juice stored at room temperature, simulating retail conditions. The stability of the vitamin in canned juice kept at room temperature and under refrigerated conditions was also investigated.

MATERIALS AND METHODS

Orange juice was extracted from fully ripe oranges using a plastic juice extractor. The pulp was removed by straining the juice through a saran cloth. A simple syrup consisting of sugar and water in a 1:1 ratio (w/w) was prepared and pasteurized at 94°C for 10 min and then cooled to room temperature. The cooled simple syrup was then mixed with the strained juice in a 1:5 ratio (v/v) so as to obtain an orange drink containing 80% (v/v) juice. The orange drink was reheated to 94°C and maintained at this temperature for 5 min.

While still hot, 1000 ml of the juice was divided into five 200-ml portions. To four of these, preweighed amounts of vitamin C stabilizers were added, such that there were experimental batches with 200 and 400 ppm of either sodium metabisulphite or L-cysteine. The remaining 200 ml batch was to serve as a control. The hot juice (with and without stabilizers) was dispensed into transparent glass vials (each of 8 ml capacity) leaving a uniform headspace of about 5 mm. The vials were sealed tightly with tight fitting screw caps. The bottled control and the bottled juice containing the two levels of cysteine and sodium metabisulphite were kept on a laboratory bench simulating retail conditions.

The remaining juice (without any additions) was filled while hot in 301 × 409 (77·8 mm × 90·5 mm) size cans leaving about 1·8 cm headspace. The cans were seamed using an MB Hand Dixie Seamer. Half of the cans were refrigerated and the rest stored at room temperature, side by side with the bottled orange drink.

On day 1, and at 1-week intervals, duplicate determinations of ascorbic acid in four samples (bottled and canned juices) were made, following the procedure described by Jagota & Dani (1982). Absorbance (blue colour) following mixing of TCA–juice filtrate with Folin–Ciocalteus reagent was determined at 700 nm using a Corning-EEL model 197 Spectra colorimeter.

The L-ascorbic acid contents (mg/100 ml of processed juice) were determined from a standard curve. Independent regression analysis for treatment data was carried out and used for predicting the juice shelf life. The slope of the regression curves represented the rates of ascorbic acid destruction in mg/100 ml of juice per week.

RESULTS AND DISCUSSION

The weekly mean ascorbic acid contents in processed orange juice during storage for 5 weeks are given in Table 1. On subjecting the data to a two-way analysis of variance (Snedecor & Cochran, 1967) it was evident that sodium metabisulphite and cysteine had a significant stabilizing effect on ascorbic acid (Table 2). Raising the sodium metabisulphite level from 200 to 400 ppm significantly increased the stability of vitamin C ($p < 0{\cdot}05$). Similar effects were observed on raising

TABLE 1
Effect of Storage Time on the Mean Ascorbic Acid Content (mg/100 ml of juice) in Bottled and Canned Orange Juice

			Storage time (weeks)					
			0	*1*	*2*	*3*	*4*	*5*
Package	*Treatment*	*ppm*	*Ascorbic acid (mg/100 ml of juice)*					
Bottled	Control		44·0	27·1	25·3	22·7	19·8	17·3
	Sodium metabisulphite	200	—	30·4	29·4	27·5	27·2	19·9
		400	—	32·5	32·4	29·4	27·8	27·5
	Cysteine	200	—	33·0	33·6	28·8	28·1	26·8
		400	—	37·9	35·9	34·0	30·4	26·3
Canned	Room temperature storage		—	30·4	27·1	26·5	25·9	25·0
	Refrigerated storage		—	35·9	34·0	33·0	32·4	30·4

the level of cysteine. Cysteine had an apparently greater stabilizing effect on vitamin C than that observed for sodium metabisulphite during the 5-week storage period. The ascorbic acid levels in canned juice stored at room temperature were significantly higher than in the bottled control ($p < 0{\cdot}05$) but were comparable with the amount in bottled juice having 200 ppm sodium metabisulphite. The refrigerated canned juice had the highest mean ascorbic acid level. The effect of storage temperature on the extent of ascorbic acid destruction has been reported for reconstituted frozen orange juice (Horton & Dickman, 1977).

Despite the stabilizing effect of the two chemicals on vitamin C in juice packed in clear/transparent bottles, there was a tendency for the vitamin to decrease with storage time as illustrated in Fig. 1. Although similar declines have been reported in aqueous and dehydrated fruit juice mixes, the rate and magnitude of decline depends on the headspace

TABLE 2

Rates of Ascorbic Acid Depletion and Probable Shelf Life in Weeks as Predicted from Independent Linear Regression Equation

	Treatment	*Correlation coefficient (r)*	*Ascorbic acid depletion rate in mg/100 ml of juice per week (slope)*	*Number of weeks to attain 'zero' ascorbic acid content*	*Mean* ascorbic acid content over the 5-week storage period*
A. Bottled (RTS)	Control	−0·997	2·51	11·9 ± 0·1	22·4[a]
	Sodium metabisulphite				
	200 ppm	−0·890	2·32	14·6 ± 0·8	26·9[b]
	400 ppm	−0·954	1·46	23·5 ± 0·5	29·9[c]
	Cysteine				
	200 ppm	−0·928	1·79	19·8 ± 0·7	30·1[c]
	400 ppm	−0·984	2·87	14·5 ± 0·3	32·9[d]
B. Canned	Room temperature storage (RTS)	−0·920	1·20	25·5 ± 0·7	27·0[b]
	Cold storage	−0·983	1·26	29·3 ± 0·3	33·1[d]

RTS, Room temperature storage.

* Means superscripted by the same letter are not significantly different.

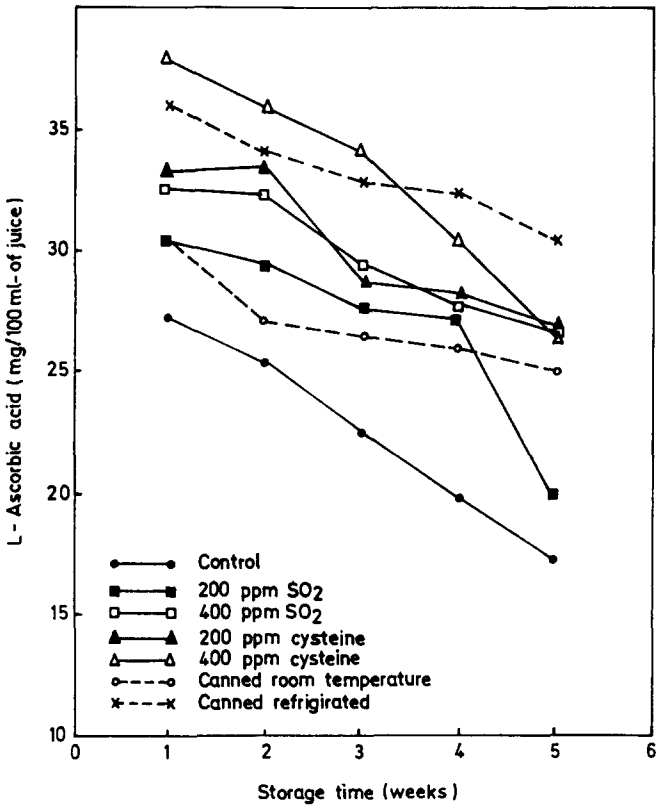

Fig. 1. Effect of storage time on ascorbic acid levels in bottled and canned orange juice.

volume and gaseous composition (Edrissi & Kooshkabadi, 1974), the nature and composition of the container package (Squires & Hanna, 1979) and the storage time (Andrew, 1977). The extent of ascorbic acid retention in glass and plastic containers has been shown to be about 90% and 20%, respectively, after 3 to 4 weeks' storage (Bisset & Berry, 1975). For a given type of container exposed to similar oxygen and light conditions, the extent of vitamin C destruction is influenced to a greater extent by the storage time (Andrew, 1977).

The stabilizing effects of cysteine and sodium metabisulphite have been manifested by their ability to maintain ascorbic acid at higher concentrations during the first 3 weeks of storage (Fig. 1). However, the effect of increasing their level on the rate of ascorbic acid depletion was

inconsistent. Juices treated with 400 ppm cysteine and 200 ppm sodium metabisulphite had similar shelf lives despite a slightly higher rate of ascorbic acid depletion in the former (Table 2). Therefore, the best criterion for comparing the stabilizing effect of the two chemicals is by comparing the respective means of ascorbic acid content over the given storage period, rather than their rates of depletion. The predicted shelf life seems to depend on the initial ascorbic acid concentration and its depletion rate. Residual oxygen in the headspace has been shown to be the primary cause for ascorbic acid destruction in pasteurized fruit juice (Kirk *et al.*, 1977; Riemer & Karel, 1978). Following the depletion of headspace oxygen, there is anaerobic decomposition of ascorbic acid (Kefford *et al.*, 1959). Under anaerobic conditions fructose and its phosphorylated derivatives have been implicated in the acceleration of ascorbic acid losses (Huelin *et al.*, 1971).

The predicted shelf life of the juice corresponds to the time it takes for complete exhaustion of ascorbic acid in the container package. These were based on independent linear regression analysis for each set of data using the ascorbic acid levels for a treatment as a dependent variable and storage time (weeks) as an independent variable. The correlation coefficients shown in Table 2 are fairly high, suggesting that the best lines of fit (which are not shown) are suitable for predicting the shelf life of fruit juices, with the predicted shelf life being represented by the x-axis intercepts. Although regression curves have been used for predicting the shelf life of ascorbic acid in packaged fruit juices (Kefford *et al.*, 1959), it is recognized that its rate of depletion in both aqueous and dehydrated food systems is not perfectly linear (Kefford *et al.*, 1959; Dennison & Kirk, 1977). Even with these shortcomings, regression lines relating fruit juice ascorbic acid levels and storage time can be a useful guide for a justifiable declaration of ascorbic acid shelf life on the package label (Squires & Hanna, 1979).

REFERENCES

Andrew, F. E. (1977). Stability of ascorbic acid in orange juice exposed to light and air during storage. *J. Amer. Diet. Ass.*, **71**(2), 140.

Bissett, O. W. & Berry, R. E. (1975). Ascorbic acid retention as related to container type. *Food Sci. & Technol. Abstr.*, **7**(6), F 273.

Cameron, D. J. (1978). Variation on storage of ascorbic acid levels in prepared infant feeds. *Food Chem.*, **3**(2), 103.

Dennison, D. B. & Kirk, J. R. (1977). Oxygen effect on the degradation of ascorbic acid in a dehydrated food system. *J. Food Sci.*, **43**(2), 609.

Edrissi, M. & Kooshkabadi, H. (1974). Determination of vitamin C in Iranian citrus fruits. *Iranian J. Agric. Res.*, **3**(2), 81.

El-Gindy, M. M. & Shehata, S. (1974). Technological and chemical studies on lime juice concentrated by freezing. *Egyptian J. Food Sci.*, **2**(1).

Goussault, B., Luquet, F. M. & Gagnepain, M. F. (1978). Effect of UV irradiation on nutrients in baby food packaged in white or brown glass. *Food Sci. & Technol. Abstr.*, **10**(6), G 339.

Gresswell, D. M. (1974). Vitamin C in soft drinks and fruit juices. In: *Vitamin C—Recent aspects of its physiological and technological importance.* (Birch, G. G. & Parker, K. J. (Eds)). Applied Science Publishers Ltd, London, 110.

Heiss, R. (1970). *Principles of food packaging: An international guide.* P. Keppler Verlag KG, Heusenstamm, Germany.

Horton, P. B. & Dickman, S. R. (1977). Stability of ascorbic acid in reconstituted frozen orange juice. *J. Food Protect.*, **40**(9), 584.

Huelin, F. E., Coggiola, I. M., Sidlue, G. S. & Kennet, B. H. (1971). The anaerobic decomposition of ascorbic acid in the pH range of foods and in more acidic solutions. *J. Sci. Food Agric.*, **22**, 540.

Jagota, S. K. & Dani, H. M. (1982). A new colorimetric technique for the estimation of vitamin C using Folin-phenol reagent. *Anal. Biochem.*, **127**, 178.

Kefford, J. F., McKenzie, H. A. & Thomson, P. C. O. (1959). Effect of oxygen on quality and ascorbic acid retention in canned and frozen orange juices. *J. Sci. Food Agric.*, **10**, 51.

Kirk, T., Dennison, D., Kokoczka, P. & Heldman, D. (1977). Degradation of ascorbic acid in dehydrated food system. *J. Food Sci.*, **5**, 1274.

Riemer, J. & Karel, M. (1978). Shelf life studies of vitamin C during food storage. Prevention of L-ascorbic acid depletion in dehydrated tomato juice. *Chem. Abstr.*, **89**(13), 1061316b.

Shah, W. H. & Zafar, S. I. (1975). Studies on the production and storage of tomato juice. *Pakistan J. Sci. Industrial Res.*, **18**(6), 272.

Snedecor, G. W. & Cochran, W. G. (1967). *Statistical methods* (11th edn), Ames, Iowa State University Press.

Squires, S. R. & Hanna, J. G. (1979). Concentration and stability of ascorbic acid in marketed reconstituted orange juice. *J. Agric. Food Chem.*, **27**(3), 639.

Timberlake, C. F. (1960). Metallic compounds of fruit juices. III. Oxidation and stability of ascorbic acid in model systems resembling black currant juice. *J. Sci. Food Agric.*, **11**, 258.

Walker, J. R. L. & Reddish, C. (1964). Note on the use of cysteine to prevent browning in apple products. *J. Sci. Food Agric.*, **15**, 902.

Zipper, A. F. (1974). The measurement of sulphur dioxide losses in fruit juices. *Food Technol. Austr.*, **26**(6), 228.