Storage Stability of Orange Juice Concentrate Packaged Aseptically

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ABSTRACT

Orange juice concentrates were packaged aseptically by a "Dole" aseptic canning machine using 6 oz metal cans. The final juice products (11°, 34°, 44°, 58° Brix) were stored between −18° and 36°C and tested periodically for nonenzymatic browning, ascorbic acid destruction, furfural and sensory changes. Nonenzymatic browning, the main deterioration phenomena in these products, was satisfactorily retarded at 12°C or lower. Ascorbic acid destruction rate constant was dependent on temperatures between 5 and 25°C, and was affected by degree of juice concentration. Furfural accumulation in juice was higher than that in 58° Brix concentrate. Orange juice concentrate of 58° Brix did not show flavor changes after storage at 5°C or 12°C for 17 or 10 months, respectively, when evaluated after reconstitution to 11° Brix.

INTRODUCTION

THE ASEPTIC PROCESSING of food products is a technique which is now applied in several food industries. The types of products processed by this method include: milk products, puddings, banana purée, and orange, apple and guava juices. Bulk aseptic storage of tomato products is no longer new (Green, 1978; Anon., 1978).

The aseptic bulk storage system for acid fluid products (tomatoes, apples and grapes) were developed by utilization of a relatively new and advanced technology for aseptic canning of foods. The process involves pulping concentration, pre-heating, de-aeration, heating to achieve microbiological and enzymatic stabilization, and cooling prior to storage. Storage of the sterilized product can be done in drums or in very large silos or tanks (20–100 tons) which have been previously sterilized by steam and/or chemicals (Lawler, 1974; Scott, 1974; Rother, 1977).

The bulk storage system reduced the problems associated with seasonal processing, and with warehouse and rehandling costs. Transferring the product to portable units, such as railcars or truck tankers which are capable of maintaining aseptic conditions for shipment purposes, reduced the cost of packaging and transportation (Rother, 1977; Anon., 1978).

A saving of 30% energy was obtained by aseptic-packaging and refrigerated storage of fruit-based products when compared with frozen storage (Robe, 1981).

The literature on citrus products, especially concentrates, processed aseptically is very limited. Lawler (1974) and Scott (1974) described a process for sterile-cold-filling of citrus juice in glass containers. Both these workers reported a better flavor in the aseptic than in the "hot pack" processed product.

For several years, aseptically processed single-strength orange juice has been marketed succesfully in TetraPak and PurePak packages and in recent years also as a concentrate (Anon., 1975; Anon., 1978). Johnson and Toledo (1975) reported that orange concentrate aseptically packaged in glass containers could be stored at 15°C for not more than 2 months without significant flavor changes.

The purpose of this research was to identify conditions that would allow the use of aseptic packaging technology as an alternative to frozen storage and bulk transportation of citrus products.

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MATERIALS & METHODS

SINGLE-STRENGTH ORANGE (var. Valencia) JUICE and concentrates of 34°, 45° and 58° Brix were produced from the same batch, in a line which comprised the following units in the order of the processed material flow: an FMC juice extractor industrial plate evaporator (A.P.V., three effects were used at temperatures of 78, 65 and 50°C with flash cooling to 15°C); product preheater; vacuum de-aerator; pasteurizer; product cooler; and aseptic filling and seaming machine (Dole, model 1302, James Dole Corporation, U.S.A.). All heat exchangers were of the plate type. Aseptic conditions during filling and seaming were achieved in the Dole machine by superheated steam.

The following condition existed along the material flow line: juice and concentrates were fed at 20°C; preheated and piped at 60°C to deaerator; de-aerated at 40 mm mercury (absolute pressure); pasteurized at 92–94°C for 30 sec; cooled and filled at 35°C; sealed under positive steam pressure and water cooled to 20°C. All products were packed in 6-oz cans, which were tin plated and coated inside with epoxy-phenolic resin. Cans were stored at −18, 5, 12, 17, 25, and 36°C, and tested over a period of 18 months. Essence recovery and add-back systems were not employed. One hundred twenty cans were prepared for each storage temperature and six of these cans were opened after each storage period.

Ascorbic acid was determined by titration with 2,6-dichlorophenol indophenol (AOAC, 1970). If the color of the juice was too dark the concentrates were diluted to 5° Brix. Furfural was determined using an improved method of Dinsmore and Nagy (1973), based on the well-known aniline acetic acid reaction with furfural. The color of juice and concentrates was determined directly by a Gardner Tristimulus Colorimeter, model KL 10. The instrument was calibrated against a white plate, L = 91.6, a = −1.8, b = + 1.8.

The flavor of samples adjusted to 11° Brix was evaluated at various times during storage by at least 25 test panelists from among department personnel; the same assessors participated in all the tests. At each session, the tasters compared two sets of the three samples by the triangle test (Kramer and Twigg, 1970). The samples were presented as reconstituted orange juice, without the addition of cut-back flavors and coded by two-digit random numbers. The panel was not trained. Instructions to the tasters were to find the different samples. the samples were tested in a room with daylight, (the caramel off-flavor appear before significant browning could be detected). The reference sample, stored at −18°C, was aseptically canned and of the same concentration as the test sample. All the results are presented on the basis of 11° Brix except those results on nonenzymatic browning. The cloud of reconstituted juice was stable during the test. The stability of the cloud on reconstituted juice was tested by "settling" in a conus tube fore 3 hr at room temperature. We don't evaluate the stability of the cloud for a longer period of time.

RESULTS & DISCUSSION

Nonenzymatic browning

Color deterioration of orange concentrates during storage at high temperatures was investigated. Browning expressed as an increase in the tristimulus attribute L showed significant changes in 58° Brix concentrate stored at 25°C for at least 200 days (Fig. 1). The 58° Brix concentrate was stable at 5° and 12°C for 18 and 12 months, respectively. Products of lower concentration, such as 45° Brix, could be stored at those temperatures for 24 and 18 months, respectively, without significant color deterioration (Kanner et al., 1978). Table 1 shows the effect of juice concentration on nonenzymatic browning at 17°C. It is well known that increasing the concentration of foods significantly enhances browning reactions (Labuza et al., 1970).

Ascorbic acid degradation

Ascorbic acid destruction in citrus products has been reported under aerobic or anaerobic conditions (Boyd and Peterson, 1945; Kefford et al., 1959, Nagy and Smoot, 1977, Nagy, 1980). Most of the experiments were done with juices, and a few on concentrates. (Curl, 1947; DuBois and Kew, 1951; Bisset and Berry, 1975). It was found that in concentrates the loss in ascorbic acid was very limited at −18°, 5° and 12°C but increased markedly at 25° and 36°C. Fig. 2 describes the results obtained from the degradation of a 58° Brix concentrate. Results show that degradation of ascorbic acid follows first-order reaction kinetics at temperature of 25°C and below. At 36°C the degradation of ascorbic acid did not describe a first order reaction.

Data (Fig. 2) on 58° Brix concentrate and other concentrates (Kanner et al., 1978) are in good agreement with the results of Nagy and Smoot (1977) on ascorbic acid degradation in stored canned single-strength orange juice, and differ from those of others (Brenner et al., 1948; Huelin, 1953), who found a first-order reaction of ascorbic acid degradation until 40°C or higher temperatures but for a few minutes only (Saguy et al., 1978). Apparently, results, (Fig. 2) differ from the others because of the long storage time. During this period many breakdown products develop from juice constituents, which seem to affect and accelerate the degradation of ascorbic acid (Clegg, 1964; 1966). The destruction of ascorbic acid was found to be affected by the degree of juice concentration (Fig. 3). Similar results were found by Curl (1947) and Saguy et al. (1978). The rate constants degradation of ascorbic acid for the first 100 days are 1.27 and 3.71 mg/wk/100g of 58° Brix concentrate stored at 17 and 25°C, respectively. The same results calculated to 11° Brix are 0.24 and 0.70 mg/wk respectively, which is about 2.6-fold higher than those in stored orange juice (Fig. 3) and 3- to 4-fold higher than those reported by Nagy and Smoot (1977).

Johnson and Toledo (1975) found a high level of degradation (64%) of ascorbic acid in orange concentrate (55° Brix) filled aseptically in glass containers, after 150 days at 15°C. With a similar product, stored for the same period of time and temperature, results of the present study showed ascorbic acid degradation of less than 10%.

Table 1—Nonenzymatic browning and furfural accumulation affected by juice concentrationstored at 17°C for 200 days[a]

Juice conc (°Brix)	Nonenzymatic browning[b] (−Δ L)	Furfural[c] (ppb)
11	0.3	590
34	3.8	305
44	4.3	260
58	5.2	196

[a] Values are the mean of three replications. The change in L was measured on the concentrates taken out of the can after mixing. −ΔL = L (zero time) — L (200 days).
[b] Significant differences at a level of 0.05 = 1.2
[c] Significant differences at a level of 0.05 = 27 ppb

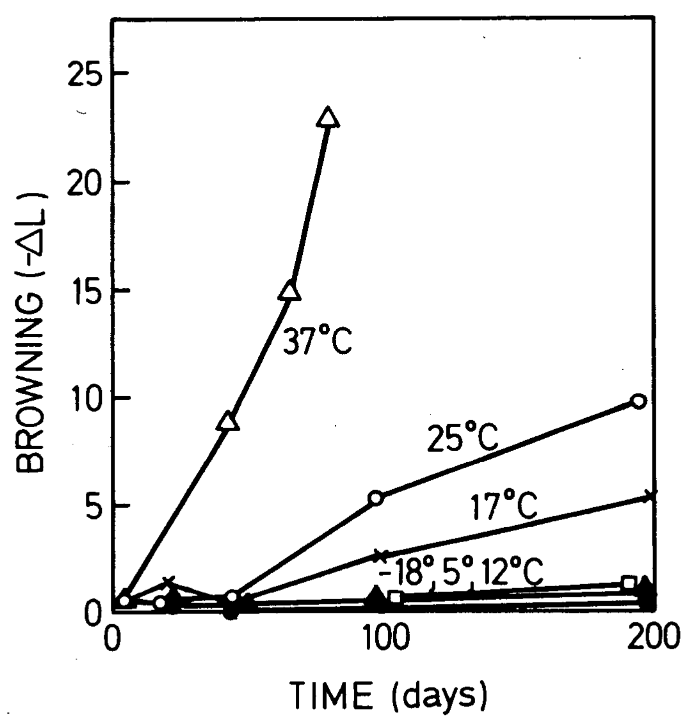

Fig. 1—Nonenzymatic browning of orange juice concentrate 58° Brix as affected by storage temperature: −18°C (•) 5°C (▲); 12°C (□); 17°C (X); 25°C (○); 37°C (△). (Values are the mean of three replications; significant differences at a level of 0.05 = 1.2).

Furfural accumulation

Blair (1964) was one of the first researchers to show that furfural accumulates during storage of citrus products. Recent reports pointed out that furfural does not directly contribute to the flavor changes but its accumulation parallels that of other compounds that alter flavor (Maraulja et al., 1973; Nagy and Randall, 1973; Nagy and

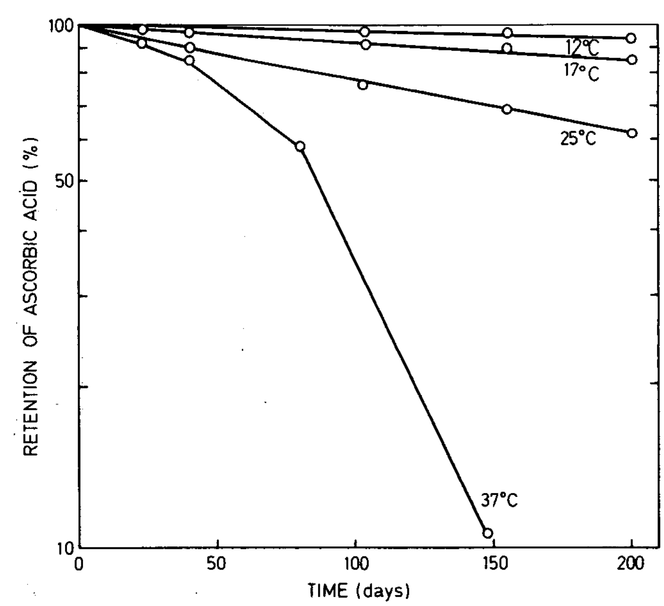

Fig. 2—Retention of ascorbic acid in orange concentrate (58°C Brix). (Values are the mean of three replications; significant differences at a level of 0.05 = 5.8%).

Smoot, 1977). There appears to be a critical temperature above which furfural accumulation is extremely rapid (Fig. 4).

In orange juice of 11° Brix, the accumulation of furfural was greater than in juice concentrate of 58° Brix (Table 1). As furfural is a breakdown product of ascorbic acid (Tatum et al., 1969) and the destruction of ascorbic acid depends on temperature and concentration, the accumulation in the 58° Brix concentrate should have been greater than in the juice. Another reason for expecting a higher accumulation of furfural in the 58° Brix concentrate was a decrease in pH which was shown by Huelin et al. (1953) to increase furfural production in a model system. Furfural is known as a reactive compound (Dunlop and Peters, 1953); in the presence of acids it tends to over condensation with aldehydes, ketones and amino acids (Rizzi, 1974).

Results of the present study indicate that further reaction of furfural with other compounds seems to have occurred at increasingly high rates with increasing product (compounds) concentration, and for this reason the accumulation of furfural was less in concentrates than in juice (Table 1); and Kanner et al., 1981).

In juice, it appears that furfural can serve as a quality deterioration index, as has been recommended by several researchers (Maraulja et al., 1973; Nagy and Randall, 1973; Nagy and Smoot, 1977); however, for concentrates this index needs further study.

Sensory quality

The concurrent changes in the flavor quality of orange concentrates filled aseptically and stored at high temperature were investigated. In contrast with Johnson and Toledo's (1975) findings, results (Fig. 5) show no statistically significant differences between 58° Brix concentrate stored at −18°C and those stored at 5°, 12° and 17°C for 17, 10, and 8 months, respectively. After this period, off-flavor was developed which was associated mainly with a caramel-like taste. Deaeration of the concentrates could account for the difference in the results of this study and that of Johnson and Toledo (1975).

Our results show that the aseptic process and storage at a refrigerated temperature could be recommended to replace the present freezing process of citrus concentrates as a means of reducing energy consumption (Robe, 1981) during production, storage, and bulk transportation.

REFERENCES

Anon. 1975. Orange concentrate in aseptic package DC builds business for Swedish dairy. Food Eng. 47: 21.
Anon. 1978. Zur kartonabfulung von fruchtsaften und nektaren. Flussinges Obst. 45: 446.
AOAC. 1975. "Official Methods of Analysis," 12th ed. Amer. Assoc. of Analytical Chemists, Washington, DC.
Belshaw, F., 1978. Interest in aseptic systems grows as energy problems approach. Food Product Develop. 12: 36.
Bisset, U.W. and Berry, R.E. 1975. Ascorbic acid retention in orange juice as related to container type. J. Food Sci. 40: 178.
Blair, J.S. 1964. Unpublished work at Fla. Citrus Exp. Sta.
Boyd, J.M. and Peterson, G.T., 1945. Quality of canned orange juice. Ind. Eng. Chem. 37: 370.

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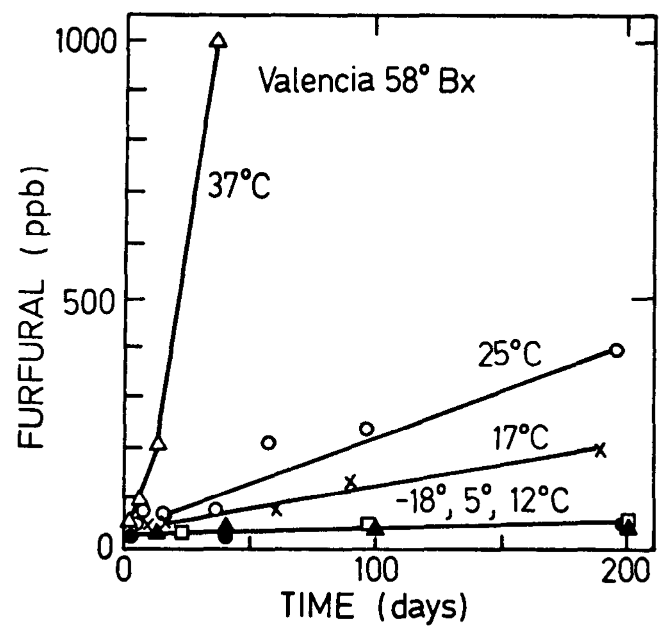

Fig. 4—Furfural accumulation in orange juice concentrate (58°C Brix) as affected by storage temperature. (Value are the mean of three replications; significant difference at a level of 0.05 = 27 ppb).

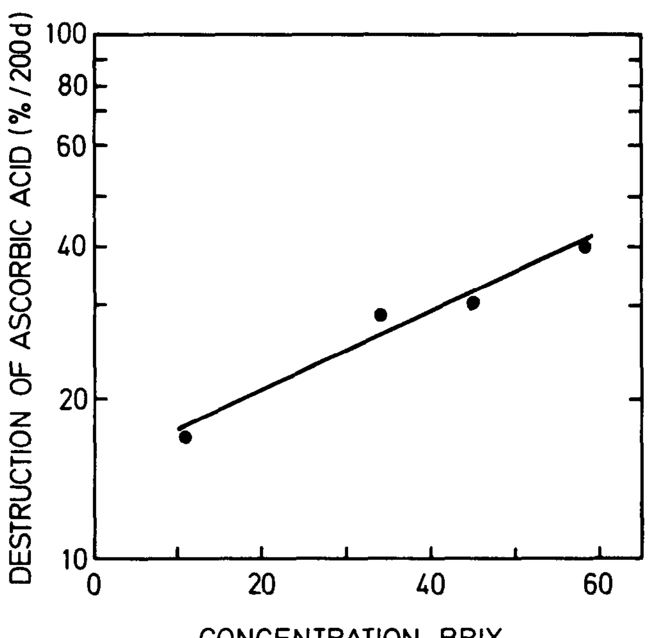

Fig. 3—Destruction of ascorbic acid in orange juices as affected by degree of concentration after storage of 200 days at 25°C.

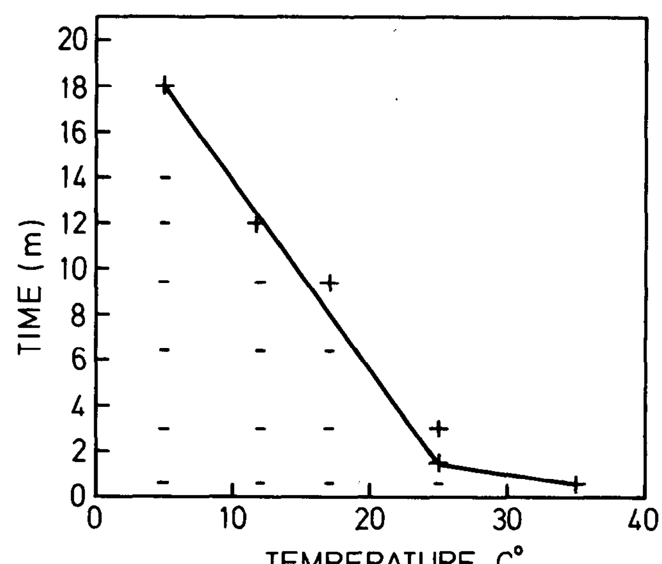

Fig. 5—Concurrent changes in the flavor quality of orange juice concentrate (58° Brix) as affected by temperature. No (−); Yes (+) statistically significant difference at a level of 0.05 between samples and the same orange juice concentrate stored at −18°C. (Time m = months).