Effect of Canning and Storage on Ascorbic Acid and Its Oxidation Products of Kinnow Juice

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The effect of processing methods and storage on the quality of canned kinnow juice was investigated. The juice was processed by exhausting and water bath heating for 5, 10, and 20 minutes at 212°F. as well as by deaerating and flash pasteurizing. The products were stored for 270 days. Reduced ascorbic acid decreased during canning in all the products. The rate of its change remained irregular throughout the storage period. The dehydroascorbic acid increased during canning and decreased to zero after 15 days of storage in all the products. The diketogulonic acid decreased to zero after canning. The contents increased rapidly during the first week, and remained irregular upto 270 days of storage in all the products. The total ascorbic acid decreased during canning operation. During storage, the rate of its change remained irregular during the first month and later it gradually decreased as the storage period enhanced. As regards quality, the fresh as well as the juice processed by deaeration and flash pasteurization was judged significantly better than those processed for 5, 10, and 20 minutes in water bath.

INTRODUCTION

The importance of citrus fruits is due to their being rich in ascorbic acid, other vitamins and also mineral matter. They are a rich source of pectin and citric acid.

Kinnow fruit is available in plenty during glut season. But the fruit cannot be made available over a longer period unless low temperature storage is carried out. Canning is one of the feasible methods for long storage of the juice but no effort has so far been made to study the suitability of kinnow juice for canning and to determine the effect of various processing treatments on its quality as well as on its storage stability. During processing and storage of citrus juices, oxidation of ascorbic acid always takes place, thereby reducing the ascorbic acid contents. The loss in quality of canned juices can be measured in terms of loss of ascorbic acid. The quality of citrus juices during processing and storage can well be obtained by determining the ascorbic acid contents and its oxidation products as well as by organoleptic evaluation of the juices. The object of the present study was to determine suitability of kinnow juice for canning and to measure the loss in quality by determining ascorbic acid and its oxidation products during storage of the canned products.

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REVIEW OF LITERATURE

Moore *et al.* (1945) found that at 40°F. the ascorbic acid retention in Florida citrus juices ranged from 96.2 to 99.0 per cent during the week while at 70°F. it was from 97.0 to 98.5 per cent for 3 days. Widerhold *et al.* (1945) noted the retention of vitamin C to be related to methods used in preparing commercial citrus juices. They observed good retention in the absence of copper. Guerrant *et al.* (1945) suggested that the vitamin contents of canned foods were preserved most effectively at storage temperature ranging just above the freezing point of respective food to approximately 42°F. Mills *et al.* (1949) observed that processed foods contained more of the oxidised forms of ascorbic acid and dehydrated foods showed the greatest amount of the inactive diketogulonic acid. It was found by Diterich *et al.* (1957) that the difference in stability of ascorbic acid (ASA), dehydroascorbic acid (DHA) and diketogulonic acid (DKA) in frozen green beans, pears, cauliflower may be due to pH differences of these commodities. Guadagni *et al.* (1957) while studying time-temperature tolerance of frozen strawberries reported the accumulation of oxidative products of ascorbic acid (DHA and DKA) during storage at elevated temperatures. Hopp (1963) found that storage period of 10-25 weeks was sufficient to make the rate of loss of vitamin C content significant in winter fruit squash. Dimair and Postel (1964) observed that degradation of ascorbic acid required oxygen and it was accelerated by heavy metals (Cu^{2+} and Fe^{3+}) and by certain oxidative enzymes. Spanyar *et al.* (1964) worked on the role of hydrogen peroxide (H_2O_2) in the decomposition of ascorbic acid. They stated that copper may catalyse decomposition of ascorbic acid to mono-dehydroascorbic acid and this compound may be decomposed by H_2O_2 to dehydroascorbic acid. Zolotova (1963) observed that when Mandarin orange and tomato juices were treated for 2 minutes with ultrasonic vibration, the vitamin C concentration decreased by 19.7 and 24.4 per cent, respectively. Mitchell (1957) while studying the problems in taste difference testing found that the Tuesday was the best day for testing taste during the week. Baker (1965) in an investigation showed that the comparative rating method would give more stable results than the scoring method.

MATERIAL AND METHODS

The fruit of kinnow mandarins was thoroughly washed, cut into halves, and the juice from each half was extracted by a Rose-head machine. The juice was then filtered first through coarse pulper and then through a fine pulper.

Canning of the Juice

For processing and canning, the juice was divided into two lots and treated as follows:

Lot No. 1. The juice was filled into No. 2 plain tin cans leaving $\frac{1}{4}$ inch head space. The cans were then exhausted to a central can temperature of 180°F. and sealed. Different lots were then processed in water for 5, 10 and 20 minutes at 212°F. respectively, and the cans were cooled to 100°F. in running cold water.

Lot No. 2. The juice was deaerated and flash pasteurised by means of a laboratory-scale glass apparatus, as is shown in Fig. 1, using vacuum pump

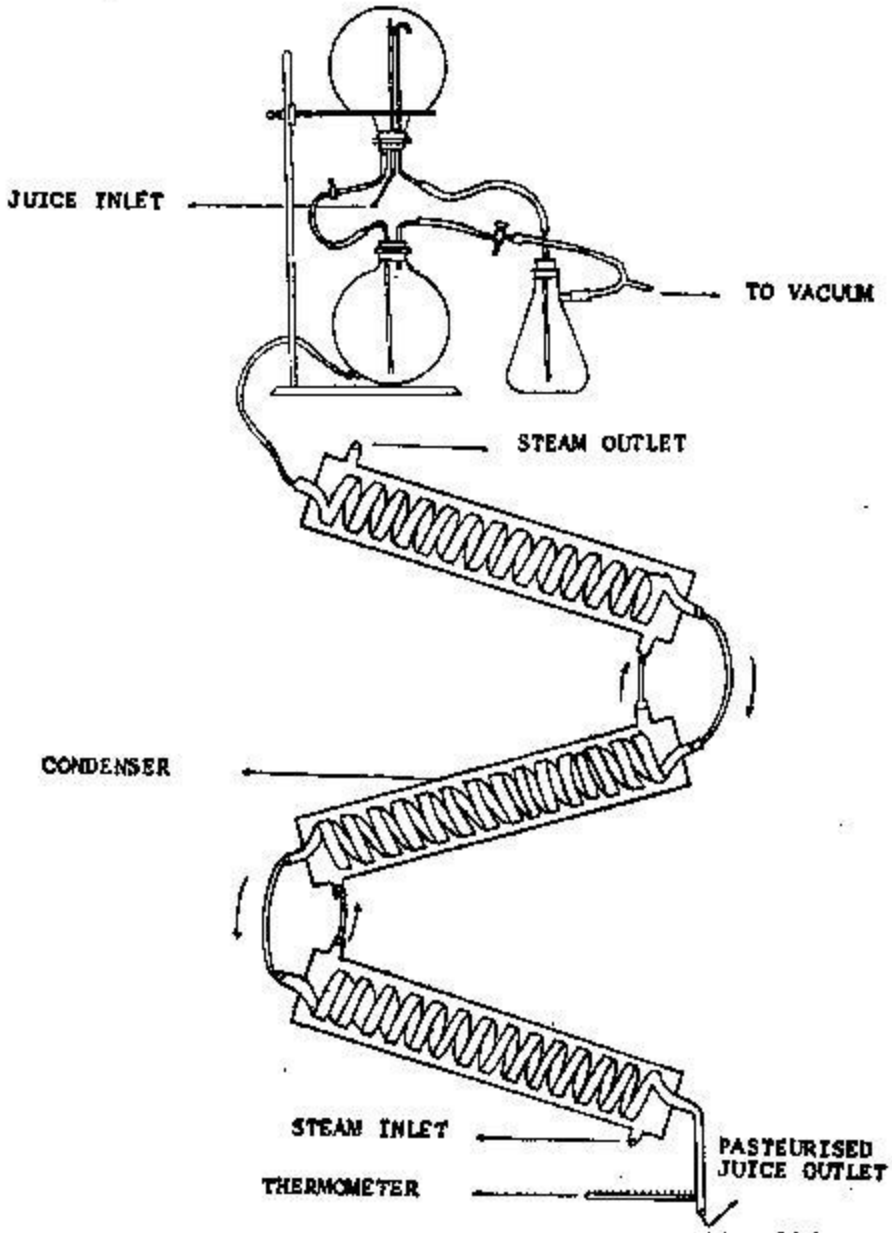

Fig. 1.—Laboratory apparatus for deaerating and flash pasteurising of juice.

and glass condensers. The juice running through the condensers was heated by live steam to an outlet temperature of 190—200°F. The juice was filled into No. 2 plain tin cans, leaving ¼ inch head space. The cans were immediately sealed at a temperature of 180—185°F. and then cooled in running cold water.

The canned products were stored at room temperature for 270 days. The fresh as well as canned juice under each treatment was analysed chemically after canning and storage of the products for 7, 15, 30, 60, 90, 180, and 270 days.

Chemical Methods

Reduced ascorbic acid (ASA), dehydroascorbic acid (DHA), and diketogulonic acid (DKA) were determined by the procedure of Roe *et al.* (1948) using Klett-Summerson photoelectric colorimeter. In this procedure, the filterate from the juice acidified with 5 per cent metaphosphoric acid and 10 per cent acetic acid solution was treated with H_2S gas to reduce dehydroascorbic acid (DHA) to reduced ascorbic acid (ASA) and CO_2 was bubbled through it to remove excess H_2S. Diketogulonic acid (DKA) was obtained by direct coupling with 2, 4-dinitrophenylhydrazine (DNPH). Thiourea was added to prevent oxidation of ASA. Dehydroascorbic acid and DKA were determined on a second portion of filterate by coupling with DNPH. After this the total of ASA, DHA and DKA was determined on a third portion of the filterate by oxidizing reduced ASA with a slight excess of bromine and then coupling with DNPH after removing excess bromine by aeration. The concentration of each component in the sample was determined from the standard curve after proper subtraction.

Organoleptic Evaluation

The canned juices under each treatment were evaluated organoleptically for colour, taste, and flavour against the standard sample, which was fresh juice, by scoring method as described by Krum (1955). The juices were evaluated organoleptically after 270 days of storage period by a panel of 10 trained judges who were presented the samples in randomised order.

RESULTS AND DISCUSSION

The data regarding the effect of processing methods as well as storage on ascorbic acid, its oxidation products and quality evaluation are illustrated in Fig. 2, 3, 4, 5 and Table 1.

EFFECT OF CANNING AND STORAGE ON DIFFERENT CONSTITUENTS

1. Ascorbic acid and its oxidation products

(i) **Reduced ascorbic acid (ASA).** The fresh juice contained 23.5 mg

ASA/100 ml of juice and during canning it is observed that the values decreased in the products under all treatments. Figure 2 shows that a slight decrease in the ASA contents occurred after 7 days of storage. On further storage up to

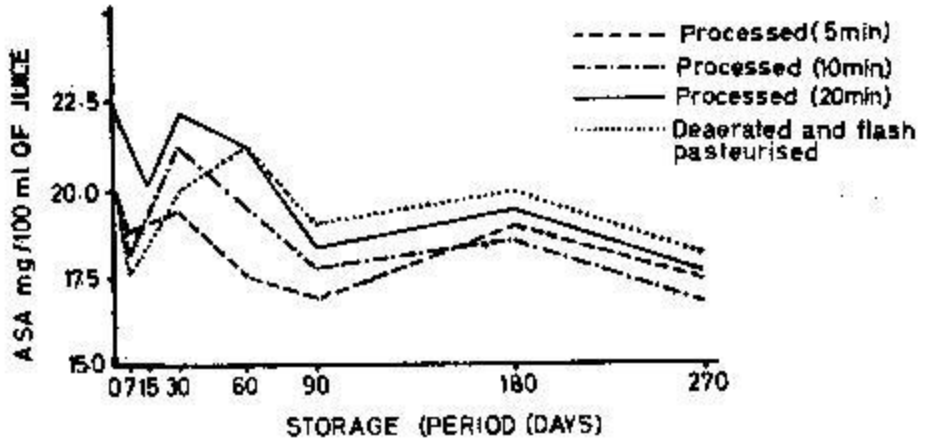

Figure 2. Effect of storage on ascorbic acid (ASA) Content of canned kinnow juice processed under different treatments.

30 days the ASA increased slightly and the values between 19.4 and 22.5 mg/100 ml. of the juice were observed. After this period a decrease was again noted in the products processed for different periods.

During storage period initially the contents slightly decreased and then an abrupt increase was observed in the first month. This initial decrease in ASA contents may be due to the oxidation of ASA to DHA by the oxygen present in the head space of the cans as well as mixed with the juice. The regeneration of ASA as observed after 15 days of storage may be due to the hydrogenation of DHA either by hydrogen donors present in the juice or by conversion of sugars and pectin to L-ascorbic acid as described by Loewus (1961). After 30 days, again the decrease was noted for the rest of the storage period. The values after 270 days of storages were observed to be between 17.0 and 18.0 mg/100 ml. of juice. The statistical analysis showed that the treatments as well as the storage durations had non-significant effect on ascorbic acid changes.

(2) **Dehydroascorbic acid (DHA).** The initial DHA contents of the fresh juice were 6.5 mg/100 ml. of juice. After canning the contents increased more in the case of juices processed for 10 and 20 minutes as compared to that processed for 5 minutes as well as deaerated and flash pasteurized. The contents were observed between 7.5 and 10.0 mg/100 ml. of the juice. The heat involved during processing of juice has been one of the factors responsible for the increase in the DHA contents after canning. It has been observed that as

the processing time increased the rate of loss of DHA decreased. In the case of flash pasteurization though the temperature was higher but the time for which the juice was exposed to this higher temperature was less. Therefore, lesser losses of DHA have been observed in this case.

The DHA contents of the products decreased on 7 days of storage and the contents have been found to be between 1.25 and 3.00 mg/100 ml. of juice, while after this period the DHA became totally absent. The data presented in Figure 3 indicate a rapid decrease in DHA after canning and the values totally reduced to zero on storage for 15 days in all the products.

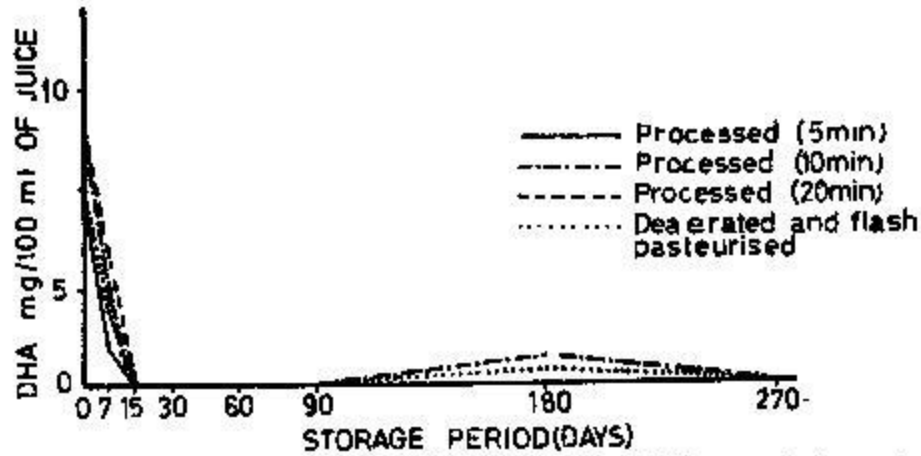

Figure 3. Effect of storage on dehydroascorbic acid (DHA) content of canned kinnow juice processed under different treatments.

It might therefore be possible that whatever DHA might have accumulated may have been converted again to ASA due to hydrogenation. It may also be possible that the oxidation of ASA was so rapid that whatever DHA was formed was rapidly converted to DKA without any accumulation of DHA. The statistical analysis of the data for DHA indicated highly significant values for storage intervals. (Table I).

(3) **Diketogulonic acid (DKA).** The fresh juice contained 3.5 mg. of DKA/100 ml. of juice. After canning no DKA was observed in the products. The total absence of DKA after canning of the products by different treatments may be either due to the rapid reaction of DKA with other constituents of the products under high heat treatment or the DKA might have converted to other products by fragmentation of its carbon chain.

The data presented in Figure 4 indicate an abrupt increase of the values under all treatments on 15 days' storage. Up to 90 days the values remained nearly constant, with slight variations, in the products under all treatments. After this period a gradual decrease is shown in Figure 4 and after 180 day's

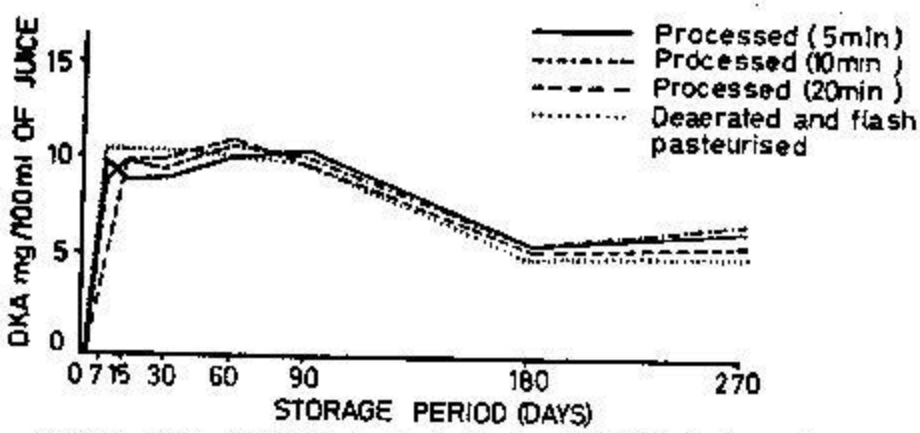

Figure 4. Effect of storage on diketogulonic acid (DKA) Content of canned kinnow juice processed under different treatments.

storage the contents further decreased and the values ranged between 5.3 and 5.5 mg/100 ml. of juice, in all the cases. The contents then slightly increased upto 270 days of storage.

The conversion of DKA into other metabolic products might be one of the factors for bringing about the decrease in DKA contents. DKA can also undergo fragmentation of its carbon chain as stated by Mills *et al.* (1949).

The statistical analysis of the data showed non-significant effect of processing methods but the storage intervals had highly significant effect on DKA contents. (Table I).

TABLE 1. *Mean Values for Oxidation Products in Canned Kinnow Juice for Storage Intervals.*

Storage Intervals	Mean value of		
	DHA	DKA	ASA+DHA+DKA*
0 ..	3.034	..	29.37
7 ..	1.976	8.53	30.50
15 ..	..	9.61	29.37
30 ..	..	9.507	30.15
60 ..	..	10.27	30.0
90 ..	..	10.07	27.71
180 ..	0.8845	5.40	24.96
270 ..	..	5.77	23.02
Last Significant difference			
at 5 per cent level ..	0.442	1.43	1.66
at 1 per cent level. ..	0.670	1.96	2.27

*ASA=Reduced ascorbic acid; DHA=Dehydroascorbic acid; and DKA=diketogulonic acid.

(4) **Total ascorbic acid (ASA+DHA+DKA).** The data on total ascorbic acid contents of canned kinnow juice processed under different treatments are illustrated in Figure 5. During canning it was observed that a decrease in total ascorbic acid occurred. The fresh juice contained 33.5 mg/100 ml. of juice.

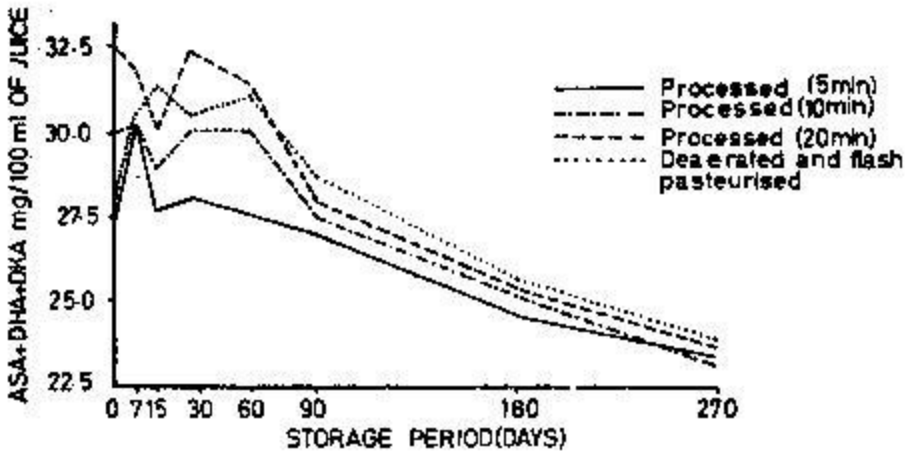

Figure 5. Effect of storage on ascorbid acid (ASA)+Dehydroascorbic acid (DHA)+ Diketogulonic acid (DKA) content of canned kinnow juice processed under different treatments.

During storage up to 15 days a slight decrease occurred in the total ascorbic acid contents of the products processed for different periods. In case of deaerated and flash pasteurized product an increase in the values was shown and the contents were 31.25 mg/100 ml. of juice. Between 15 and 30 days of storage, a slight increase in the total ascorbic acid was observed in the products under all the treatments. After this as shown in Figure 5 total ascorbic acid gradually started decreasing throughout the rest of the storage period. After 270 days, the contents were almost the same in all the products and the values were found to be between 23.0 and 23.125 mg/100 ml. of juice. The statistical analysis of the data showed that the effects of processing methods and storage intervals on total ascorbic acid were highly significant (Table I.)

2. Organoleptic evaluation

The overall effect of canning and storage of the products for 270 days at room temperature was highly significant on the acceptability of canned juice The fresh juice as well as the juice processed by deaeration and flash pasteurization were judged as significantly better than those processed for 5, 10 and 20 minutes.

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