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Factors Affecting the Stability of Vitamin C in Tropical Fruit Juices and Nectars

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INTRODUCTION

The preservation of foods is one of the most valuable contributions of science to the welfare of mankind. This contribution had been achieved mainly by the inactivation of enzymes and micro-organisms which account for the spoilage of foods.

Two of the most successful methods used in controlling these enzymes and micro-organisms are the application of heat and the elimination of oxygen. However, it is also realized that heat causes some undesirable changes in the quality of foods, especially the partial destruction of the vitamins which are essential in the human diet.

Heat at specific temperatures causes a considerable loss of vitamin C, whereas other factors, such as the vitamin C content and the Brix value, seem to have a favorable effect on the stability of this vitamin.

REVIEW OF LITERATURE

Reported studies of the stability of vitamin C in foods are abundant. Malakar (*1*)[2] indicated that blanching of some Indian vegetables in acid of 3 to 5 pH had the best effect on the retention of ascorbic acid; otherwise the loss amounted to 23 percent. Fitting and Miller (*2*) found that acerola juice had little or no effect upon the color or flavor of the fortified juices of pineapple, passion-fruit, and guava. However, sugar appeared to have some stability effect upon the color of frozen acerola juice.

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2 Italic numbers in parentheses refer to Literature Cited, pp. 11-2.

Nutting *et al.* (*3*) stated that tomato products containing from 5.6 to 38.4 percent of total solids consistently had lower flavor and color scores the more concentrated the juice. On the other hand, the retention of ascorbic acid was greater in the less concentrated juices. Du Bois and Murdock (*4*) reported that ascorbic acid was highly stable in 58.5° Brix orange-juice concentrate. The cloud of 58.5° Brix concentrated orange juice with a pulp content of 10 to 12 percent stored at 80°, 60°, and 40° F., was considerably more stable than that of 42° Brix concentrate. Lamden *et al.* (*5*) found that fermentation with yeast considerably enhanced the stability of ascorbic acid in orange juice stored at room temperature.

Sánchez-Nieva (*6*) stated that pasteurization of the acerola juice induced a change in color and flavor of the juice, accompanied by a slight loss of ascorbic acid. Asenjo *et al.* (*7*) reported that the loss of ascorbic acid and dehydroascorbic acid during cooking varied from a maximum of 82.1 percent in the dwarf Jamaica banana to a minimum of 25.6 percent in the native pumpkin. Bartilucci and Foss (*8*) found that ascorbic acid is most stable in high concentrations of propylene glycol with distilled water, glycerine, or sorbitol. The optimum pH for stability of ascorbic acid was found to be above 6 but below 7.

Shizuko (*9*) reported that vitamin C was stable in increasing order: In steam-sterilized tangerine juice, in juice containing a preservative, and in juice being fermented. Bhatia (*10*) reported that jackfruit (*Artocarpus integrifolia*) bulbs canned with 50° Brix syrup fortified with 50 mg. per 100 gm. of ascorbic acid retained about 80 percent of the vitamin after processing. Pai (*11*) found that vitamin C loss was greater in cooking by direct heat than during steam-cooking in an ordinary cooker or pressure cooker. Bender (*12*) reported that the deterioration of vitamin C in a fruit squash, composed of orange juice diluted from a concentrate of natural juice, sucrose, citric acid, and oil of orange, pasteurized in bulk, and preserved with SO_2, when stored under conditions encountered in commercial practice, was 20 percent after 12 months, 40 to 50 after 18 months, and about 60 percent after 2 years. Added synthetic vitamin C displayed the same instability.

Timberlake (*13*) found that the relative stability of ascorbic acid in black currant juice may well be ascribed to the low natural copper content of the juice, coupled with its high citrate content; this should lessen the catalytic effects of copper and also of iron. Seidemann and Feldhiem (*14*) showed that the stability of vitamin C in fruit juices, fortified with 150 mg. per 1,000 ml. of synthetic 1-ascorbic acid at different levels of sucrose concentrations ranging between 5 and 60 percent, and stored for 6 months, increased with increasing sucrose.

MATERIALS AND PROCEDURES

HEAT TREATMENT OF SOLUTIONS CONTAINING DIFFERENT QUANTITIES OF SYNTHETIC VITAMIN C OR l-ASCORBIC ACID

Three groups of solutions were prepared, each group consisting of 14 Erlenmeyer pyrex flasks containing solutions of synthetic vitamin C or l-ascorbic acid ranging from 10 to 4,000 mg. per 100 ml. This range is comparable with the vitamin C contents of tropical fruits, especially acerola, the richest fruit known in vitamin C content (2,000 to 4,000 mg. per 100 gm.) These solutions were prepared by dissolving adequate quantities of synthetic vitamin C in distilled water to obtain the desired concentration. The contents of vitamin C were determined in each solution by chemical analyses.

The groups were treated as follows:

1. Each sample of the first group was boiled for 1 minute.
2. Each sample of the second group was placed in an incubator for 10 minutes at 250° C.
3. Each sample of the third group was placed in an incubator for 15 minutes at 250° C.

The percentage of vitamin C was determined after each treatment.

HEAT TREATMENT OF DIFFERENT JUICES AND NECTARS FORTIFIED WITH DIFFERENT QUANTITIES OF SYNTHETIC VITAMIN C

Canned guava, mango nectars, and acerola juice prepared at the Food Technology Laboratory of the Agricultural Experiment Station of the University of Puerto Rico, as well as commercial canned juices of tomato, grapefruit, orange, lemon, and pineapple obtained from the local market, were analyzed to determine the contents of vitamin C. Each juice and nectar was fortified with synthetic vitamin C as shown earlier. All the samples were incubated for 15 minutes at 250° C., cooled, and then analyzed to determine their content of vitamin C.

Exposure to Air

Two groups of solutions containing synthetic vitamin C were prepared in the manner described above. Each sample of the first group was canned in a tin-plate can No. "211 x 304" and stored at room temperature, whereas samples of the second group were placed in open Erlenmeyer flasks and stored at room temperature. The percentage of vitamin C was determined at 3-day intervals for a period of 1 month.

pH Adjustments

Eight groups consisting of 14 samples each were prepared as described above. The pH of each group was adjusted to a specific level ranging from 3 to 10, by adding either hydrochloric acid or sodium hydroxide. The percentage of vitamin C was determined in all samples before and after the incubation as above.

TABLE 1.—*The effect of different heat treatments on the destruction of synthetic vitamin C in distilled water*

Boiled for 1 minute			Incubated for 10 minutes at 250° C.			Incubated for 15 minutes at 250° C.		
Before heating	After heating	Loss	Before heating	After heating	Loss	Before heating	After heating	Loss
Mg. per 100 ml.	*Mg. per 100 ml.*	*Percent*	*Mg. per 100 ml.*	*Mg. per 100 ml.*	*Percent*	*Mg. per 100 ml.*	*Mg. per 100 ml.*	*Percent*
8.7	3.2	63.2	6.7	0.6	91.0	11.2	2.2	80.4
13.5	8.2	39.2	15.6	5.9	62.2	16.3	3.9	76.1
19.1	12.4	35.0	20.9	10.7	48.8	20.9	6.1	70.8
24.0	18.1	24.6	25.6	14.9	41.8	25.7	8.3	67.7
29.4	23.4	20.4	35.8	23.7	33.8	35.9	12.8	64.3
37.8	29.1	23.0	56.6	40.6	28.3	56.9	46.9	17.6
48.0	39.7	17.3	76.7	63.1	17.1	94.3	83.0	11.9
57.8	49.3	14.7	95.0	81.6	14.1	144.9	130.8	9.7
80.5	71.0	11.8	141.9	125.7	11.4	192.7	176.8	8.3
99.3	88.7	10.7	194.4	177.6	8.6	240.7	219.0	9.0
146.0	134.4	7.9	239.7	222.5	7.2	287.6	265.9	7.5
196.0	180.9	7.7	286.0	269.6	5.7	385.8	371.9	3.6
253.7	230.6	9.1	485.6	468.3	3.6	478.0	460.6	3.6
298.9	275.0	8.0	726.6	715.4	1.5	724.7	691.7	4.6
501.2	470.1	6.2	976.3	959.0	1.8	966.3	936.8	3.1
750.0	738.3	1.6	1,458.4	1,448.1	.7	1,461.7	1,414.7	3.2
1,000.8	991.0	1.0	1,948.3	1,925.0	1.2	2,070.0	2,036.9	1.6
1,500.8	1,501.6	—	2,923.8	2,901.3	.8	3,100.4	3,065.4	1.1
2,000.8	1,996.3	.6	3,438.7	3,418.0	.6	3,617.4	3,577.0	1.1
2,981.8	2,990.8	—	3,900.1	3,913.0	—	4,122.5	4,090.3	.8

Brix Adjustments

Distilled water and guava nectar were fortified with synthetic vitamin C to about 100 mg. per 100 ml. The mixture was then divided into 10 samples each. Different quantities of sugar were added to each sample to form a series of solutions having Brix value ranging between 15 and 60°. Vitamin C was determined in each sample before and after the incubation as before.

Chemical Analyses

The vitamin C content was determined by the iodate method, as modified by Ballentine (*15*).

RESULTS AND DISCUSSION

The results of the effect of heat treatment upon the destruction of vitamin C in distilled water, as well as in juices of acerola and orange, are shown in tables 1 and 2, and figure 1. Vitamin C was destroyed at a higher rate when the concentration of vitamin C was below 200 mg. per 100 ml. This phenomenon was observed throughout this experiment, regardless of the differences in time and temperature.

TABLE 2.—*The percentage of vitamin C lost by orange and acerola juices upon heating for 15 minutes at 250° C.*

Orange juice			Acerola juice		
Before heating	After heating	Loss	Before heating	After heating	Loss
Mg. per 100 ml.	*Mg. per 100 ml.*	*Percent*	*Mg. per 100 ml.*	*Mg. per 100 ml.*	*Percent*
12.5	8.0	36.0	20.6	13.7	33.5
28.4	23.6	16.9	31.8	24.4	23.3
59.3	54.8	7.6	42.4	33.3	21.5
101.6	96.2	5.3	63.2	55.3	12.5
111.0	100.8	9.2	92.3	81.4	9.5
137.5	122.8	10.7	115.1	104.5	9.2
168.2	154.6	8.1	123.7	112.0	9.5
205.0	191.3	6.7	209.6	201.0	4.1
282.7	270.7	4.2	249.1	244.8	1.7
333.9	325.4	2.5	317.0	313.5	1.1
398.8	375.8	5.8	419.2	414.9	1.0
709.7	673.0	5.2	515.4	499.9	3.0
895.8	877.9	2.0	836.7	807.5	3.5
1,437.3	1,392.0	3.2	987.9	967.2	2.1
1,749.8	1,731.9	1.0	1,340.0	1,293.7	3.5
2,561.1	2,531.3	1.2	1,811.6	1,759.2	2.9
2,997.5	2,956.5	1.4	2,864.8	2,669.8	6.8
3,411.7	3,381.8	.9	3,531.3	3,267.6	7.5
3,784.9	3,754.2	.8	4.079.4	3,765.9	7.7
4,292.2	4,263.2	.7	4,429.0	4,051.0	8.5

The same trend is shown in figure 2, wherein it appears that vitamin C in canned nectars of guava and mango, as well as in canned juices of tomato, grapefruit, orange, lemon, and pineapple, was destroyed at a higher rate when the concentration was less than 200 mg. per 100 ml.

Figures 3 and 4 show that the rate of destruction of vitamin C was much higher in solutions exposed to air than in those stored in sealed cans. However, the percentage destruction was much higher in solutions containing lower concentrations of vitamin C.

The determination of vitamin C in solutions having different pH values ranging from 3 to 10, as shown in figure 5, indicated that the rate of destruction of vitamin C was not appreciably affected by pH. The trend of destruction was about the same, regardless of the differences in pH.

The degrees Brix had a noticeable effect on the rate of destruction of vitamin C, as shown in figure 6: the higher the Brix value, the lower the

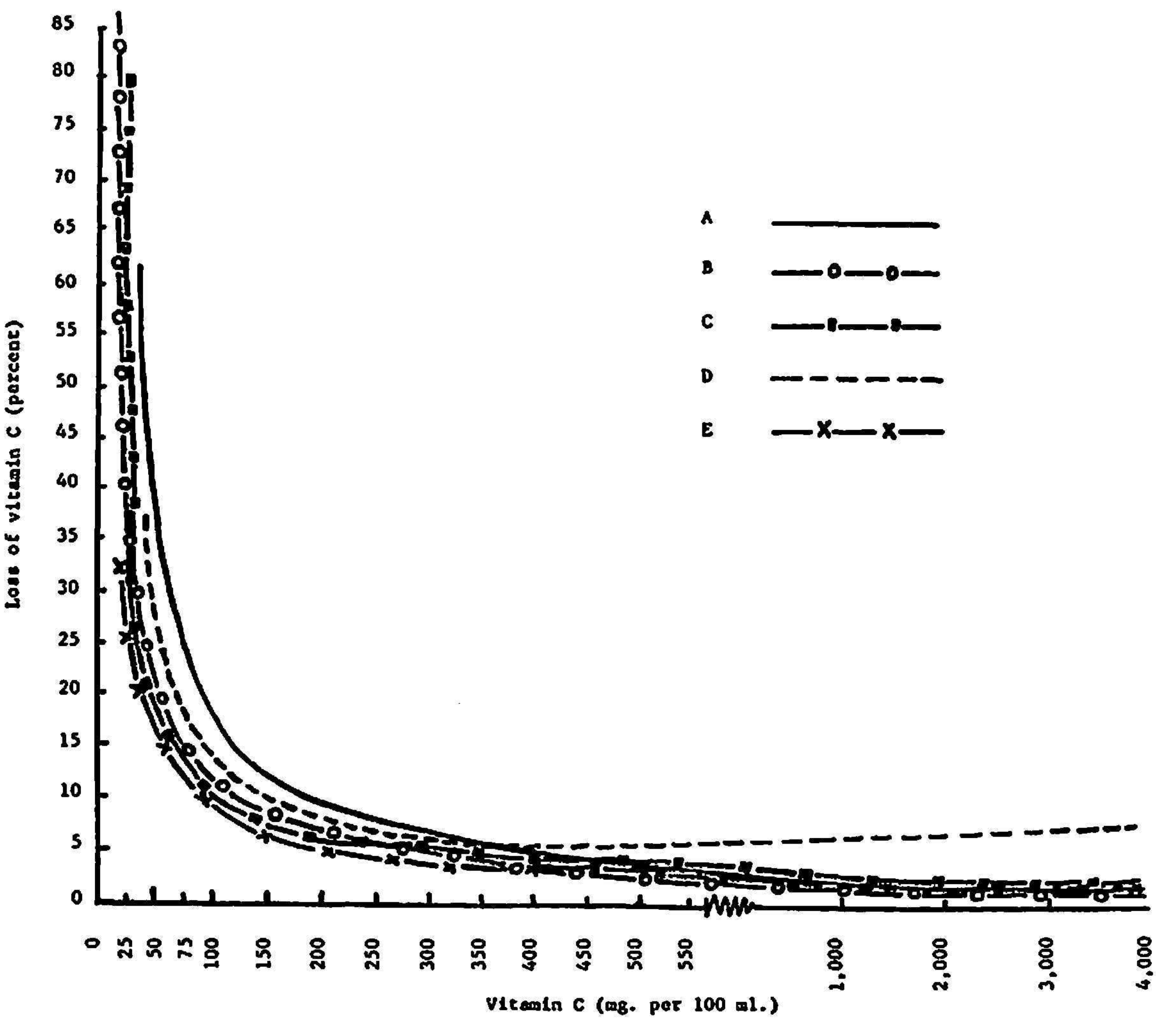

FIG. 1.—The trend of destruction of vitamin C as affected by heat: A, Vitamin C in distilled water boiled for 1 minute; B, vitamin C in distilled water incubated for 10 minutes at 250° C.; C, vitamin C in distilled water incubated for 15 minutes at 250° C.; D and E, vitamin C in orange juice and acerola juice, respectively, incubated for 15 minutes at 250° C.

percentage of vitamin C losses. These findings, that the concentration of vitamin C in fruit juices and nectars has a noticeable effect on the stability of this vitamin, might be of significant value in food-processing, especially where fortification with vitamin C is practiced.

SUMMARY

Studies were conducted on the effect of certain factors such as temperature, pH, degrees Brix, concentration of vitamin C, and storage in sealed

as well as in open containers, on the stability of vitamin C in tropical fruit juices and nectars. They were fortified with different quantities of synthetic vitamin C (l-ascorbic acid) ranging between 10 and 4,000 mg. per 100 ml. The results were as follows:

1. In solutions which received the following treatments: Boiled for 1 minute, incubated for 10 minutes at 250° C., and incubated for 15 minutes at

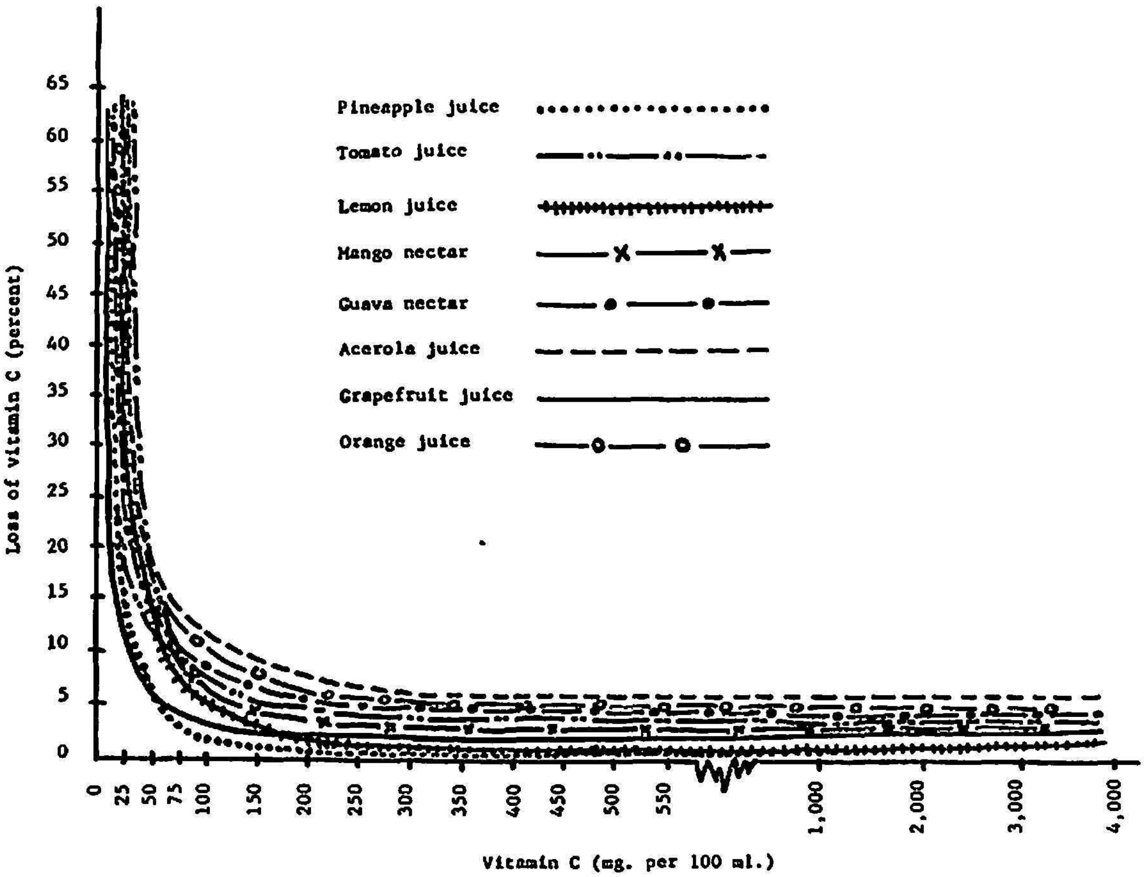

FIG. 2.—The trend of destruction of vitamin C in different fruit juices and nectars as affected by heating for 15 minutes at 250° C.

250° C., vitamin C at concentrations below 200 mg. per 100 ml. was destroyed at the highest rate.

2. The highest rate of destruction occurred at concentrations below 200 mg. per 100 ml. in juices of fruits, such as orange, pineapple, lemon, grapefruit, acerola, and tomato, as well as in nectars of mango and guava, fortified with synthetic vitamin C and incubated for 15 minutes at 250° C.

3. The pH of solutions containing synthetic ascorbic acid was adjusted to 3, 4, 5, 6, 7, 8, 9, and 10, and then they were incubated for 15 minutes at 250° C. The pH did not appreciably affect the rate of destruction of the vitamin. However, there was a similar trend at all pH levels. Vitamin C at lower concentrations had the highest percentage of destruction.

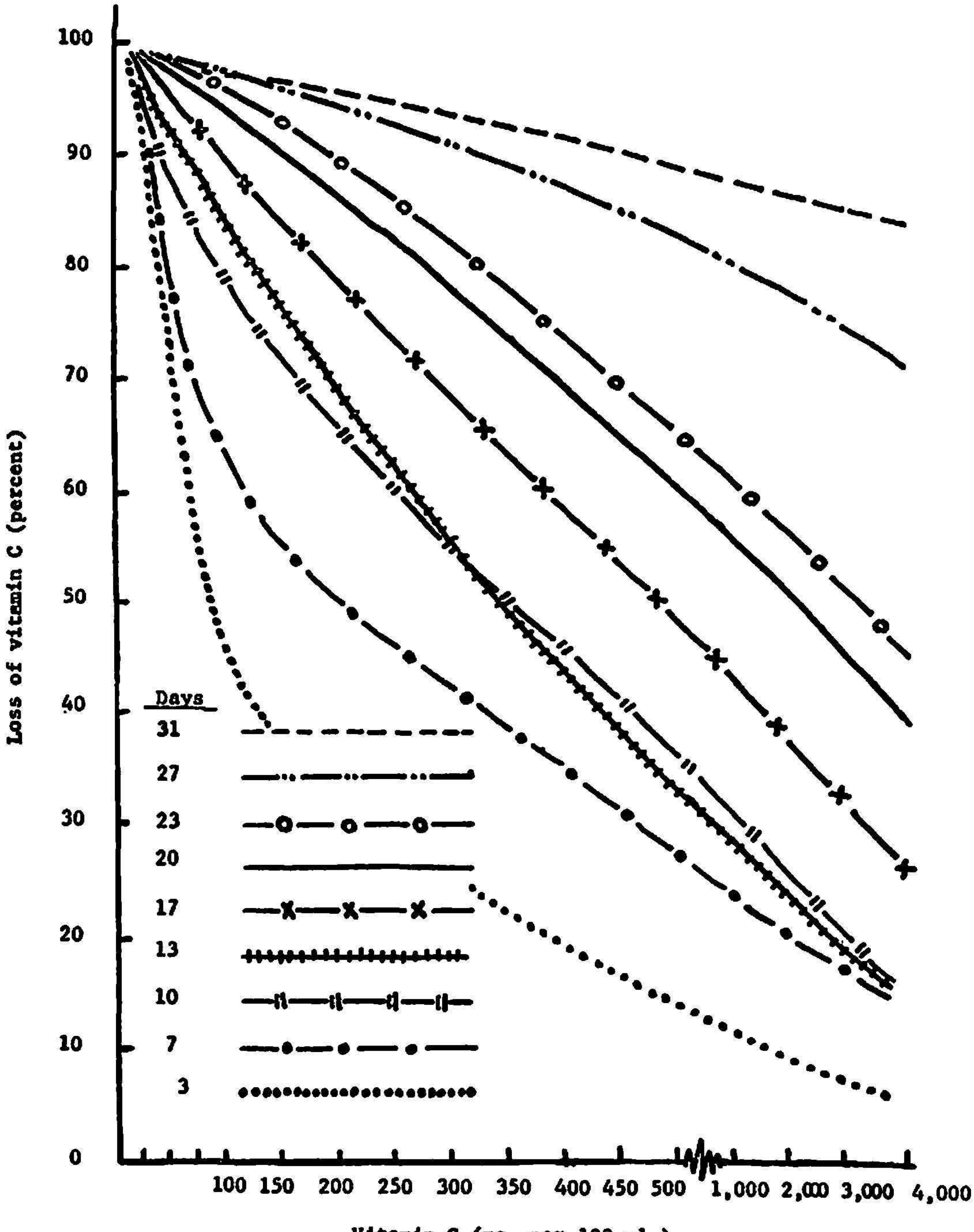

FIG. 3.—The rate of destruction of vitamin C in distilled water as influenced by storage in open containers for different periods of time ranging from 3 to 31 days.

4. The destruction of vitamin C in solutions stored for 1 month in sealed, as well as in open containers was higher in samples having lower concentrations of the vitamin. However, samples which were exposed to the air had much greater losses of vitamin C than those stored in sealed containers, regardless of the concentration of vitamin C.

5. Less destruction of vitamin C occurred in samples having higher degrees of Brix. The concentration of vitamin C in tropical fruit juices or nec-

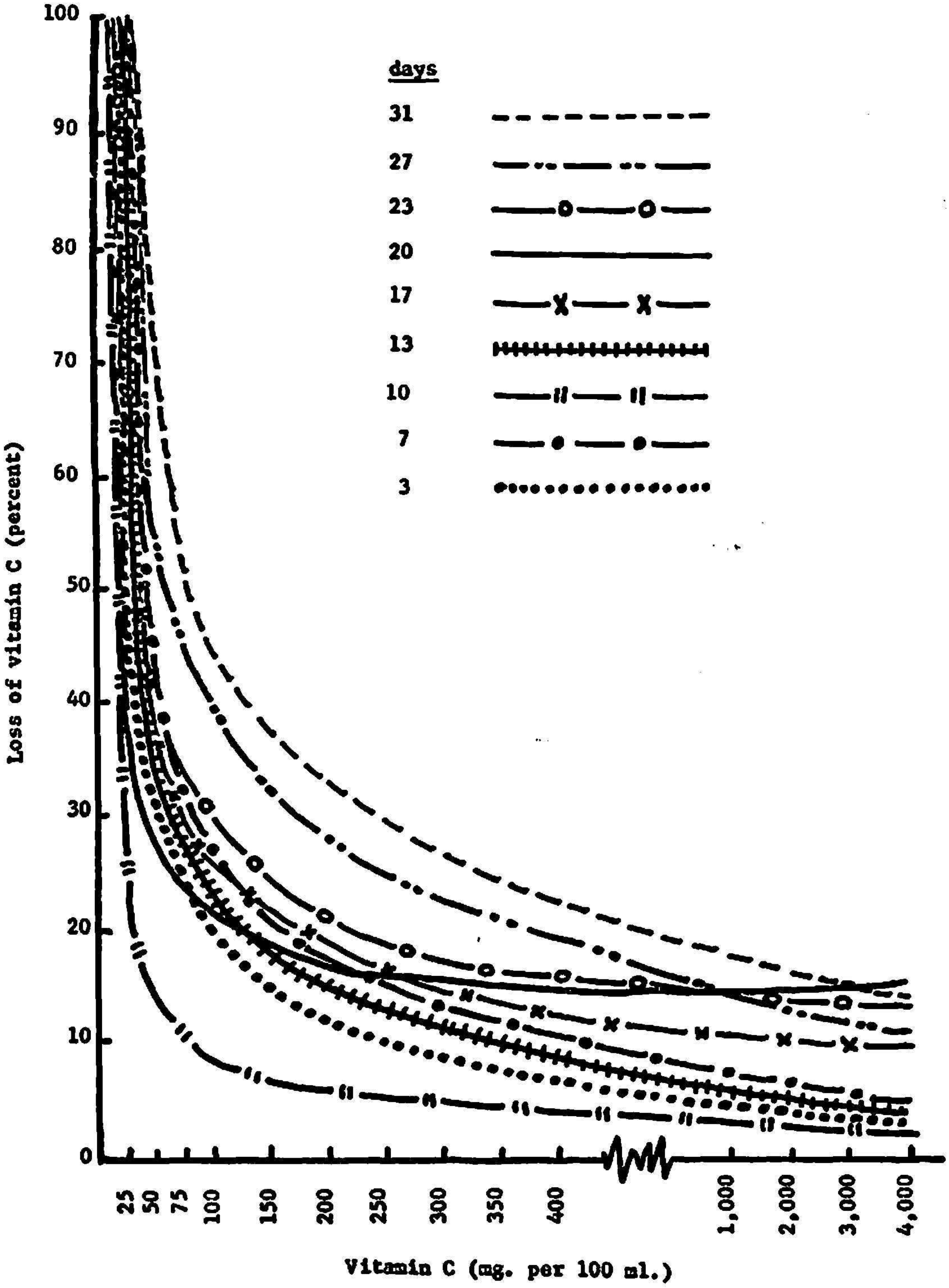

FIG. 4.—The rate of destruction of vitamin C in distilled water as influenced by storage in sealed containers for different periods of time ranging from 3 to 31 days.

tars has a definite effect on the destruction of vitamin C. Hence, the destruction of vitamin C is not proportional to its concentration.

RESUMEN

Se llevaron a cabo experimentos para determinar el efecto de la temperatura, pH, concentración de sólidos solubles, cantidad de vitamina C y

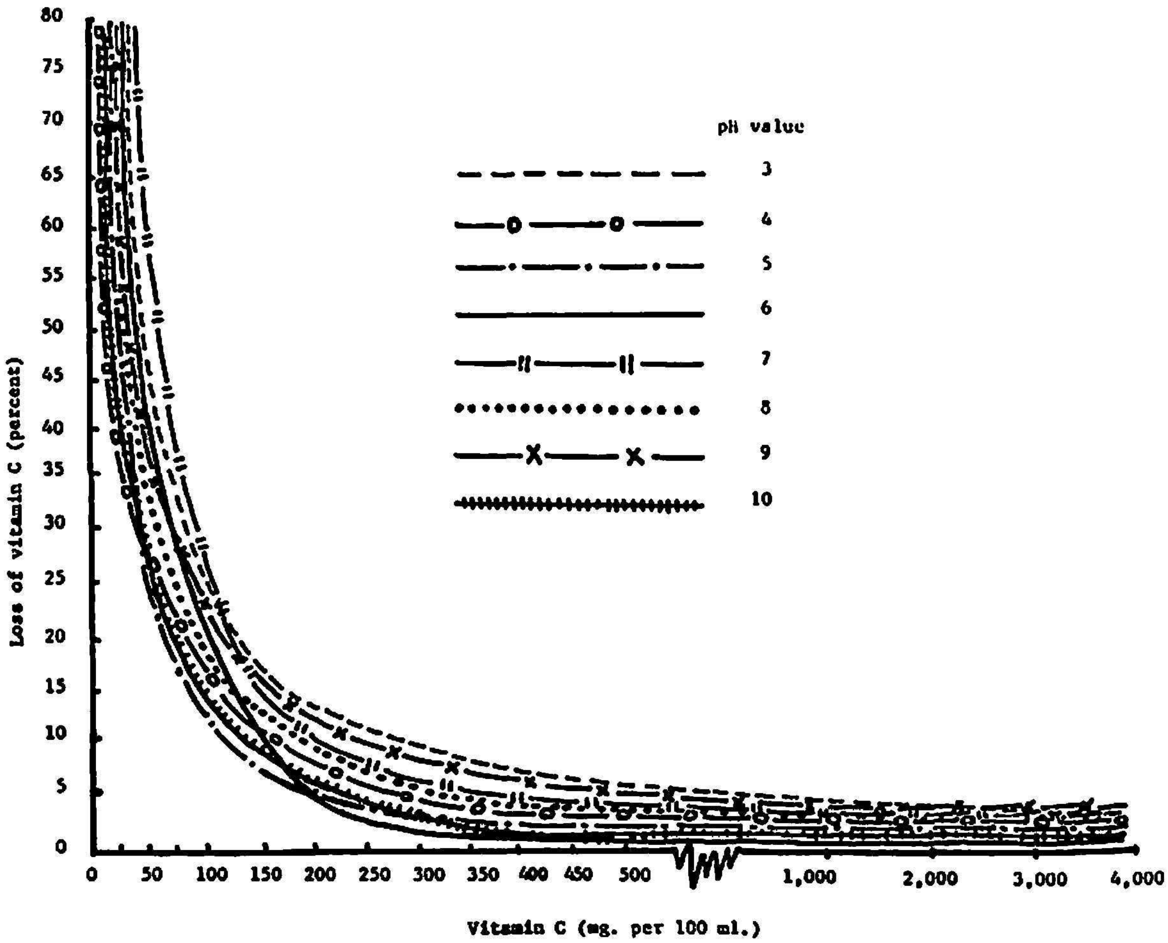

FIG. 5.—The effect of pH upon the rate of destruction of vitamin C in distilled water heated for 15 minutes at 250° C.

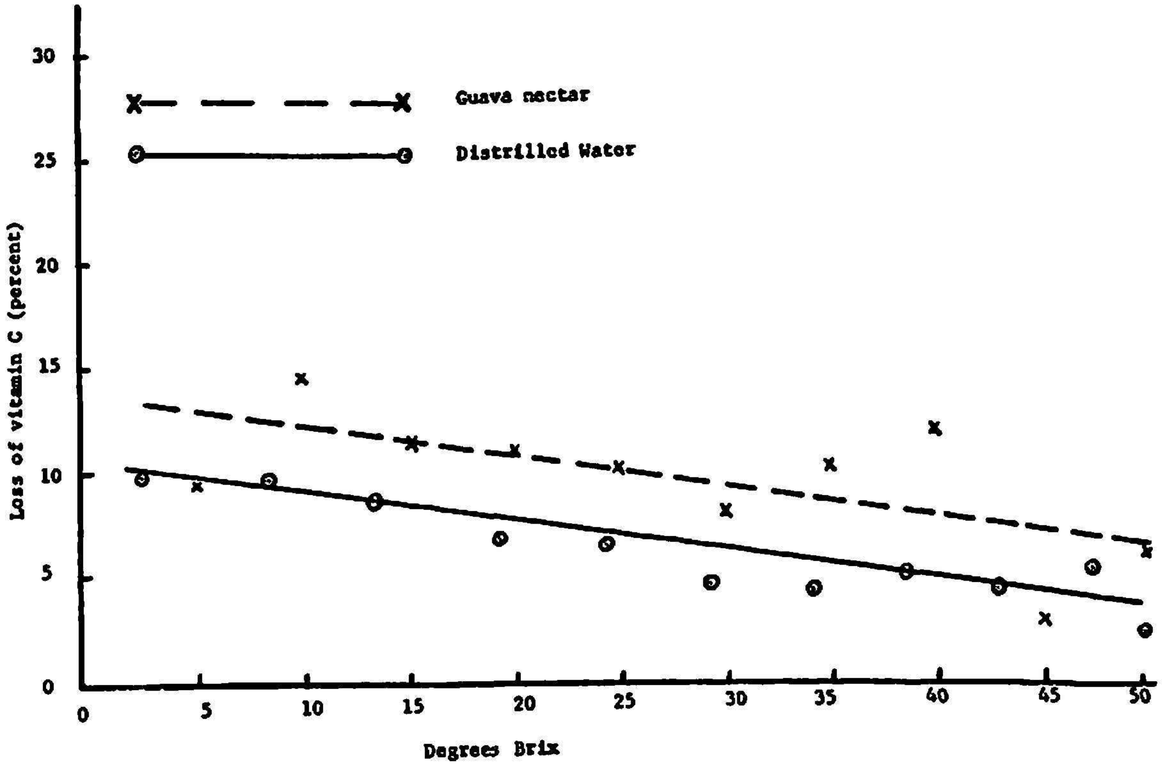

FIG. 6.—The effect of degrees Brix upon the rate of destruction of vitamin C in distilled water and guava nectar incubated for 15 minutes at 250° C.

almacenamiento en envases abiertos y sellados herméticamente sobre la estabilidad de la vitamina C en los jugos y néctares de frutas tropicales. Los productos se fortificaron con cantidades de vitamina C sintética que fluctuaron entre 10 y 4,000 mg. por cada 100 ml. Los resultados fueron los siguientes:

1. Las soluciones que hirvieron por un minuto, las cuales se mantuvieron a una temperatura de 250° C. por 10 minutos y 250° C. por 15 minutos, demostraron que la vitamina C en concentraciones menores de 200 mg. por cada 100 ml. se destruyen con la mayor facilidad.

2. Los jugos de china, piña, limón, toronja, acerola y tomate, al igual que los néctares de mangó y guayaba fortificados con la vitamina C sintética y mantenidos a una temperatura de 250° C. por 15 minutos, demostraron que la destrucción máxima de la vitamina C tiene lugar a concentraciones menores de 200 mg. por cada 100 ml.

3. El pH de las soluciones que contenían ácido ascórbico sintético se ajustó a 3, 4, 5, 6, 7, 8, 9, y 10, manteniéndose éstas a una temperatura de 250° C. por 15 minutos. Los resultados demostraron que el factor pH no influyó sobre la rapidez con que se destruyó la vitamina C. Demostraron, sin embargo, la misma tendencia hacia una mayor destrucción de la vitamina C a concentraciones menores en todos los niveles de pH estudiados.

4. La destrucción de la vitamina C en productos almacenados por un mes, tanto en envases sellados herméticamente como abiertos, fue mayor en las muestras con más bajas concentraciones de vitamina. No obstante, las muestras expuestas al aire demostraron mayores pérdidas de la vitamina C que las selladas herméticamente, sin importar el grado de concentración de la vitamina.

5. Hay menos destrucción de la vitamina C en las muestras con el mayor contenido de sólidos solubles. La concentración de la vitamina C en los jugos y néctares de frutas tropicales tiene un efecto definitivo sobre la destrucción de ésta. Concluímos que la destrucción de la vitamina C no es proporcional a su concentración en el producto.

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