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STUDIES ON THE UTILIZATION OF GRAPE PART III. INVERSION OF SUCROSE BY GRAPE JUICE

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In the commercial juice preparation from *Concord* grapes produced in Watari region of Miyagi Prefecture, sucrose has been usually added to juice because grapes in this region are very sour, as reported in Part I (1). The procedures of grape juice preparation were in detail reported in Part II (2).

From our many analyses of commercial grape juices, it was found that sucrose added to juice had been almost inverted. The following experiments were made for the purpose of ascertaining whether this inversion resulted from the action of invertase or the hydrolysis by organic acids in the juice during pasteurization.

Concerning the invertase in grape juice, Hozumi *et al.* (3), Martinaud (4) and Berg (5) had reported on its presence, but not in detail.

Experimental

I. Sucrose Inversion by Fresh Grape Juice

Juice samples were prepared from *Concord* grapes, harvested in October 1953, by pressing lightly with hands and also by pressing its pomace more strongly.

The analytical values of these juices are shown in Table 1. From the results, it should be noticed that the sugar content in strong-pressed juice is somewhat less than light-pressed juice, but total acidity in the former is nearly twice as much as the latter.

Table 1. Chemical Composition of *Concord* Grape Juices

	pH	Total acid (as tartaric) g/100ml	Reducing sugar (as invert) g/100 ml
Light-pressed juice	3.0	0.55	7.55
Strong-pressed juice	2.8	1.00	7.01

The experimental procedures used to investigate the sucrose inversion by light and strong pressed juice, are as follows :

First, 10 ml of the sucrose solution which contains 65.75 g per 100 ml total sugar (as invert) and 2.73 g per 100 ml reducing sugar (as invert), is added to 20 ml of juice. The mixtures are held for 30 minutes at 30°, 55°, 65°, 75° and 85°C, respectively, and then brought in the thermostat which is kept at 30°C. Then, they are analysed periodically. The inversion ratio is calculated from total invert sugar and reducing sugar (as invert).

The results are illustrated in Figure 1 and 2. (Hereafter, sugar is shown as invert.)

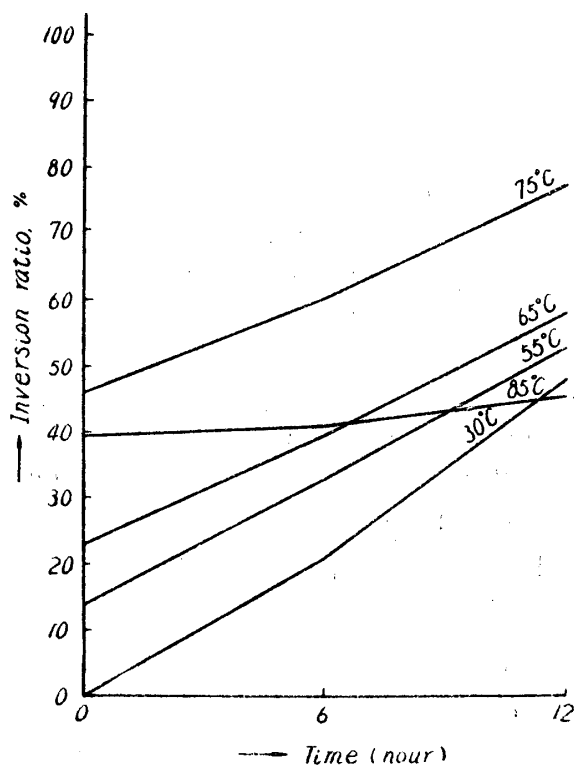


Fig. 1. Graph of Sucrose Inversion by Light-Pressed Juice

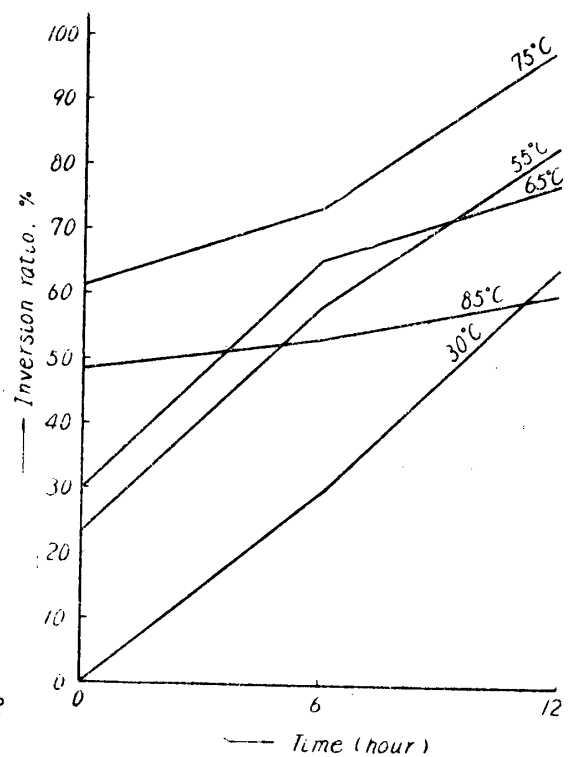


Fig. 2. Graph of Sucrose Inversion by Strong-Pressed Juice

II. Sucrose Inversion by Original Grape Juices of Commercial Products

Original grape juices used for this investigation were prepared in several factories of Watari region in 1953. The preparation method of these juices, as described in Part II, was that the hot-pressed juice was separated from argols and other sediments, put into containers without addition of sucrose and pasteurized.

The chemical composition of original juices (five varieties) are shown in Table 2.

Table 2. Chemical Composition of Original Grape Juices Prepared in Watari Region of Miyagi Prefecture

	pH	Total acid (as tartaric) g/100 ml	Reducing sugar (as invert) g/100 ml
A	2.4	1.06	9.15
B	2.4	1.27	11.03
C	2.2	1.49	10.98
D	2.3	1.40	9.38
E	2.3	1.27	9.28

To examine the sucrose inversion, a certain volume of juice is added to its half volume of the sucrose solution which contains 69.35 g per 100 ml total sugar and 2.37 g per 100 ml reducing sugar, and the mixture is held under toluene at 30°C for 3 hours. Total sugar and reducing sugar are determined at regular intervals. Changes in inversion ratio with elapsed time are illustrated in Table 3.

Table 3. Inversion Ratio of Sucrose by Original Grape Juices at 30°C

	24 hrs. %	48 hrs. %	72 hrs. %
A	21.61	27.55	32.47
B	25.98	32.25	38.31
C	25.84	30.41	36.92
D	22.68	27.72	33.06
E	23.31	28.69	33.49

Next, the sucrose inversion at 75°, 80° and 85°C was examined in the same manner. In this case, sucrose was directly added to the original juice which had 10.31 g per 100 ml reducing sugar, 1.29 g per 100 ml and pH 2.3. This mixture contained 48.25 g per 100 ml total sugar and 8.61 g per 100 ml reducing sugar. Results are summarized in Table 4.

Table 4. Inversion Ratio of Sucrose by Original Grape Juice at 75°-85°C

75°C	Time, min.	10	20	30	40	50	60
	%	4.27	10.37	13.40	17.75	22.32	24.10
80°C	Time, min.	14	21	28	35	42	49
	%	12.30	19.77	24.27	29.25	34.94	39.87
85°C	Time, min.	5	10	15	20	25	30
	%	6.28	14.75	22.74	31.35	39.85	47.74

III. Sucrose Inversion by Tartaric and Malic Acid

The sucrose inversion by tartaric and malic acid which are main organic acids in grape juice ought to be investigated for the comparison with grape juice.

(a). Sucrose Inversion by Tartaric Acid

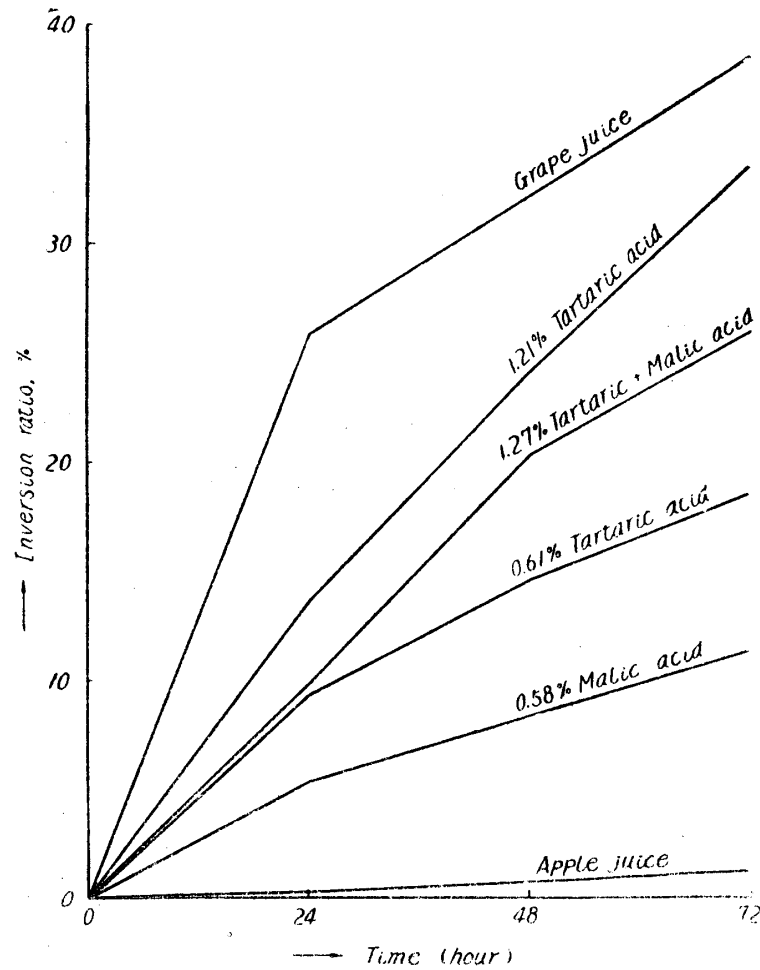


Fig. 3. Graph of Sucrose Inversion at 30°C

Solution A, which possessed 49.82 g per 100 ml total sugar, 1.83 g per 100 ml reducing sugar, 1.21 g per 100 ml tartaric acid and pH 1.5, and B which possessed 49.62 g per 100 ml total sugar, 1.74 g per 100 ml reducing sugar, 0.61 g per 100 ml tartaric acid and pH 2.2, were kept at 30°C and 80°C. They were analysed periodically. Results are shown in Figure 3 and 4.

(d). *Sucrose Inversion by Malic Acid*

In the use of solution C which possessed 50.54 g per 100 ml total sugar, 1.79 g per 100 ml reducing sugar, 0.58 g per 100 ml malic acid and pH 2.2, inversion ratio at 30° and 80°C was examined in the same way as tartaric. Results are shown in Figure 3 and 4.

(c). *Sucrose Inversion by Mixture of Tartaric and Malic Acid*

Sucrose solution which contained both tartaric and malic acid was prepared. Its composition was as follows: 48.96 g per 100 ml total sugar; 1.64 g per 100 ml reducing sugar; 1.27 g per 100 ml total acid (tartaric : malic = 1 : 1); pH 1.5. Inversion tests were made at 30°, 75°, 80° and 85°C. Results are given in Figure

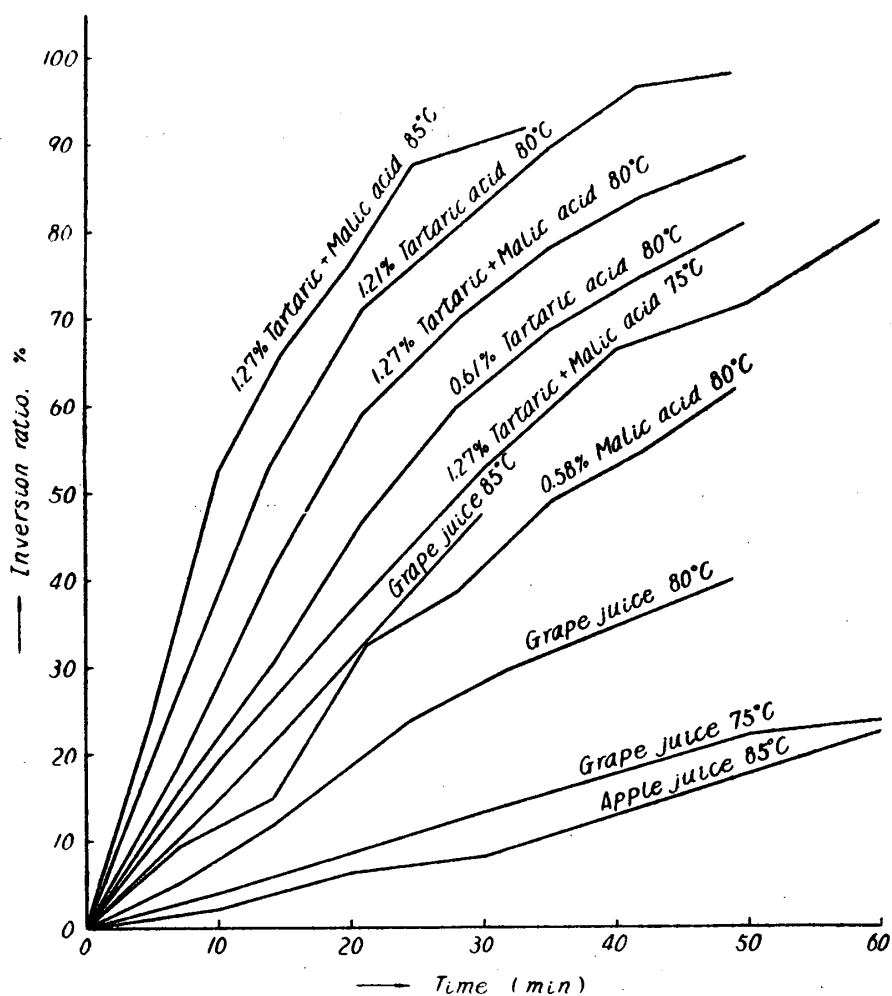


Fig. 4. Graph of Sucrose Inversion at 75°, 80° and 85°C

3 and 4.

IV. Sucrose Inversion by Apple Juice

Sucrose inversion by apple juice was also examined in order to compare with grape juice. *Rolls Janet* apples, produced in Aomori Prefecture in 1953, were washed, cored, crushed, pressed, centrifuged and separated from precipitates. The resulting juice was prepared with addition of sucrose and then used for inversion test. Sugar content of these fresh and sucrose-added juices were determined (Table 5).

Inversion ratios at 30° and 80°C are shown in Figure 3 and 4, respectively.

Discussion

From Figure 1 and 2, there is no doubt that fresh grape juice possesses a strong invertase activity which is destroyed by heating to 75° to 85°C. Therefore, the line of 85°C shows the inversion by organic acids contained in juice. In Figure

Table 5. Chemical Composition of Apple Juice and its Sugar-Added Juice

	A		B	
	fresh juice	sugar-added juice	fresh juice	sugar-added juice
pH	3.3	—	2.9	—
Reducing sugar, (as invert) g/100 ml	7.93	6.95	8.73	9.25
Total sugar, (as invert) g/100 ml	11.80	48.13	12.60	38.15

A is the sample for sucrose inversion test at 30°C and B at 80°C.

1 and 2, it is also shown that the strong-pressed juice is stronger in the inversion ability than the light-pressed juice. One of this reason is likely that the former is higher in acid content than the latter.

In general, sucrose added to commercial grape juice has been almost inverted by the action of acids in juice although invertase has been already destroyed by pasteurization. However, *Lemonas'* concentrated grape juice, which was reported in Part I, contained considerable amount of sucrose. Since this juice was flash-pasteurized, instantly bottled, flash cooled and stored at low temperature, sucrose inversion could not be probably promoted.

As clearly shown in Figure 3 and 4, sucrose inversion ability of tartaric acid is stronger than malic.

These facts are very important from the standpoint of taste. In the preparation of sweet juice or imitation juice, the taste difference between sucrose and invert sugar, the taste difference among organic acids, various combinations of organic acids with sugars, influence of organic acids on Vitamin C, here-mentioned sucrose inversion, etc. must be considered.

In the case of apple juice, its invertase activity is very slight (see Figure 3). Moreover, since the acid in apple juice consists of malic acid exclusively and its content is less than in grape juice, the sucrose inversion ability of the former is naturally weaker than the latter.

Summary

In the use of the *Concord* grapes produced in Watari region of Miyagi Prefecture, inversion of sucrose by grape juices was investigated. It was ascertained that sucrose added to the fresh grape juice was inverted strongly by its own enzyme which was destroyed at 75° to 85°C. In the case of the commercial pasteurized grape juice, the enzyme activity was almost lost and the added sucrose was inverted by tartaric and malic acid contained in the juice; tartaric acid showed stronger inversion ability than malic.

Furthermore, inversion ability of fresh apple juice was also tested. The results indicated that both the enzymic and acidic inversion abilities in apple juice were very much weaker than those in grape juice.

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