STUDIES ON THE UTILIZATION OF GRAPE PART IV. PRODUCTION OF GRAPE JUICE FOR DRINK (2)

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By

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As previously reported (1), the experimental production of juice for drink from *Concord* grapes havrested last year (1953) did not give good results. This experiment was also made on the principle of the previous production method, but some sections of essence recovery equipment were improved to afford more facilities for operation. In the production of red grape juice from *Concord* grapes, the hot-pressing of crushed grape mass is the ordinary procedure for developing fully the characteristic *Concord* color and aroma. Nevertheless, in this experiment both hot- and cold-pressing were examined, using the stemmed or unstemmed grapes. Changes of sugar, acid, tannin, color and aroma in each stage of production process were investigated. Comparison among the various production methods was also discussed from the standpoint of recovery of each component and organoleptical test. After all, the result of this experiment offered one of the production methods which was thought to be advantageous to the industrial production of grape juice for drink.

In color measurement with a spectrophotometer, the most desirable preparation of the sample was investigated to avoid the change of color character by the clarification and dilution of juice. The color values of juice were represented, according to Omata and Ueno (2) and Yamazaki (3), as DC, RC, color distribution ratio and total DC.

Experimental

[I] Measurement of Juice Color

Color was measured as follows: Readings were taken in 14.4 to 14.7 mm inside diameter test tubes with Hitachi Spectrophotometer EPO-B in the optical density range of 0.15 to 0.70. The readings in this ragne could minimized the error of measurement. The color values were represented as follows: DC,

* The original report is now in the press in the Journal of Fermentation Technology (Osaka, Japan).

the sum of optical densities in all filters; RC, DC ratio of the processed juice to the original; color distribution ratio, optical density of each filter × 100/DC; total DC, the product of DC and dilution ratio of juice.

In color measurement with a spectrophotometer, it was necessary that the *Concord* grape juice should be clarified and diluted up to the suitble degree because of the deep color. However, since the clacrification and diltion of juice might at the same time give rise to the change of color character, the following examinations were made to see the influences of clarifing treatment and acidity in the dilution on the color values.

(1) *Influence of Clarifing Treatment on Color*

The turbidity of grape juice is mainly due to the pectic substances. By the use of pectolytic enzyme or ethanol as clarifing reagents, the samples were prepared as follows:

(a) Add 30 ml of ethanol to 5 ml of juice and allow it to stand for 10 minutes after vigorous strirng.

(b) Add 30 ml of 2 per cent Sclase extract* to 5 ml of juice and maintain it at 0°C for 24 hours.

(c) Add 5 ml of 2 per cent Sclase extract to 5 ml of juice, keep at 0°C for 24 hours, and again add 25 ml of ethanol.

(d) Use 25 ml of water instead of ethanol in sample c.

(e) Add 30 ml of 2 per cent Sclase extract to 5 ml of water. (Control for sample b)

(f) Subtract the optical density of sample e in each filter from that of sample b. This value agrees with that of sample b which contains no absorption equivalent to the optical density readings of the Sclase extract.

After the above treatment, all these samples had the dilution ratio of 1 : 6. The centrifuged upper clear liquors were poured into test tubes, followed by color measurement. The absorption values throughout the entire visible range were determined with the spectrophotometer.

Table .1 Absorption value of grape juice clarified by pectolytic enzyme or ethanol

Filter No. / Sample	43	47	50	53	55	57	61	66	DC
a	0.376	0.330	0.320	0.305	0.289	0.228	0.134	0.057	2.039
b	0.440	0.364	0.357	0.304	0.273	0.172	0.097	0.044	2.051
c	0.675	0.600	0.570	0.515	0.482	0.370	0.220	0.093	3.525
d	0.530	0.480	0.490	0.430	0.380	0.246	0.128	0.059	2.745
e	0.146	0.085	0.067	0.050	0.045	0.036	0.036	0.022	0.481
f	0.294	0.279	0.290	0.254	0.228	0.136	0.067	0.022	1.570

It is noticed in Table 1 that the absorption of b is higher within the shorter

* Pectolytic enzyme solution was extracted with water from Sclase of Sankyo Seiyaku Co. at 0°C for 24 hours.

wave-length range (from filter No. 43 to 53) than a, but a is higher throughout all filters than f. In the comparison of c with d, the former is higher in absorption values than the latter. These facts inform that the enzyme clarification causes the decrease of absorption more than the ethanol clarification. Therefore, the ethanol clarification is more suitable as a clarifing reagent. The difference of the absorption value between a and c exceeds the absorption of enzyme solution, i.e. sample f, which is supposed to result from the difference of ethanol concentration between a and c.

Then, further attempts to see the relation between ethanol concentration and DC were made by measuring the optical density of juice in various ethanol concentrations at the dilution ratio of 1 : 9 (Fig. 1). At the same time, the relation between ethanol concentration and color distribution ratio also was recorded (Fig. 2). These results indicate that when the ethanol concentration is beyond 60 per cent, the absorption has a tendency to decrease rapidly. Therefore, 40 to 50 per cent of ethanol concentration is appropriate to the clarification of juice for color measurement.

(2) *Influence of Acidity on Color*

The relation of DC and color distribution ratio with acidity was ascertained in the following experiment.

After the juice was clarified by ethanol (final concentration 60 per cent) and centrifuged, ethanol was removed under vacuum. Juice volume was made with water up to the original volume. Then, the mixture of tartaric and malic acids, in which 20 per cent of both were contained, was added, and then water was added until the juice was diluted to 1 : 9, and afterwards color measurement was made by the aforementioned way. Final acidities of diluted juice varied in the range of 0.14 to 3.8 per cent as tartaric acid. The relation of DC with acidity is illustrated in Fig. 3 and the relation of color distribution ratio with acidity in Fig. 4.

As known from Fig. 3, the decrease of acidity results in the simultaneous increase of DC value. It is also noticed in Fig. 4 that the increase of acidity causes the increase of absorption in filter No. 50 (wave-length range of 495 to 510 mμ) and No. 53 (525 to 540 mμ) ,and the decrease in filter No. 43 (420 to 440 mμ), No. 57 (565 to 575 mμ) and 61 (600 to 615 mμ). In such acidity range as the color distribution ratio shows a large variation, DC value also varies largely. The variation of acidity is always accompanied with the variation of DC and color distribution ratio. Therefore, it is concluded that the juice color should be measured at the same acidity as the original juice.

(3) *Discussion on Color Measurement and Its Representation*

Although the representation of juice color may be made by DC and the dilution ratio of the juice at the time of measurement, the variation of dilution ratio brings about complication to the comparison among many samples. This

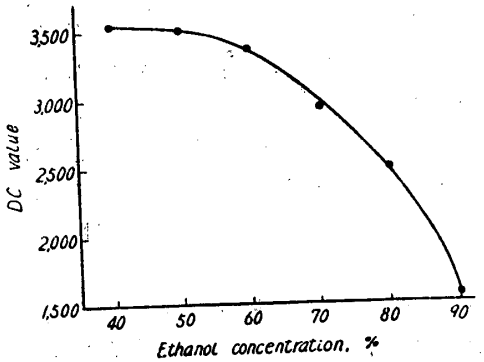

Fig. 1. Relation between DC and ethanol concentration

complication, however, will be eliminated by the application of total DC, i.e.product of DC and dilution ratio, which is to be constant independently of the variation of the dilution ratio if no change of color character takes place by the preparation method of sample.

Thereupon, using three varieties of marketed juices (Welch's grape juice of U. S. A. (W), Tokyo Shokuhin grape juice of Japan (To) and Torys concentrated grape iuice of Japan (T)), the relation between total DC and dilution ratio was examined. The sampes of these juices for color measurement were prepared in two ways, namely series-A (W-A, To-A and T-A) was adjusted at 50 per cent of ethanol concentration and the same acidity as the original, and series-B (W-B, To-B and T-B) was diluted only by ethanol without adjustment of acidity.

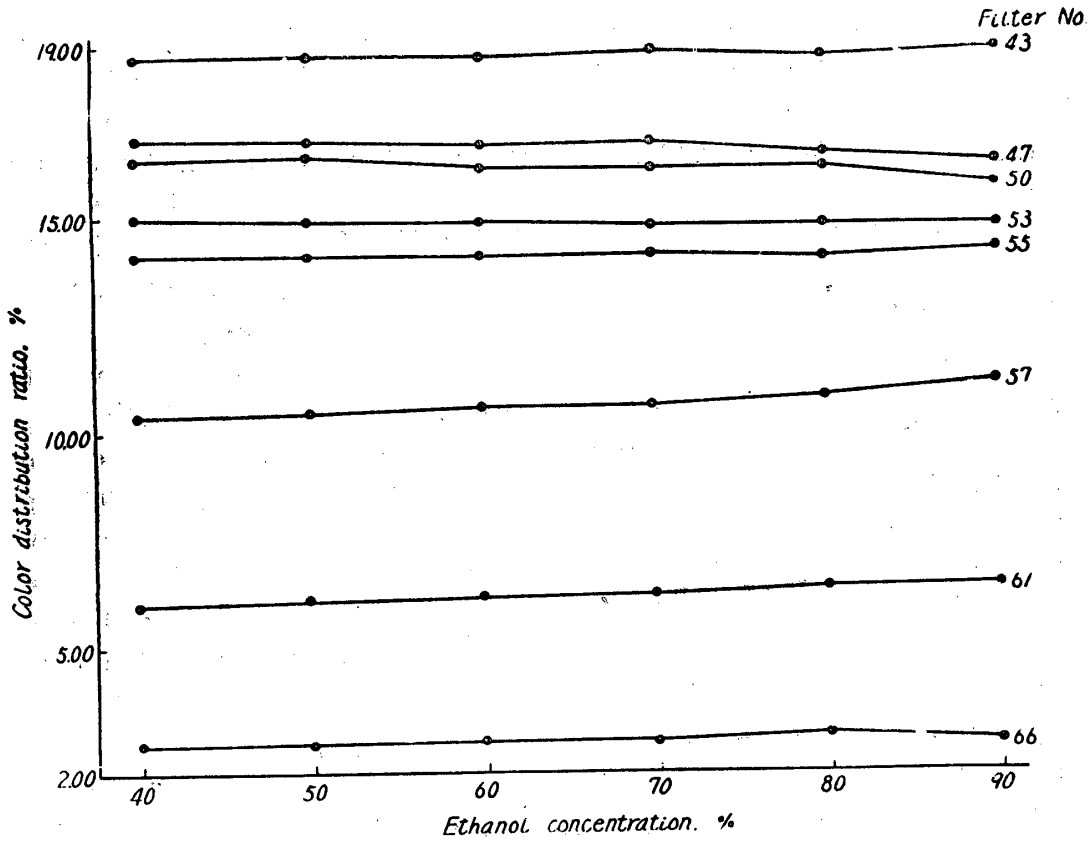

Fig. 2. Relation between color distribution ratio and ethanol concentration

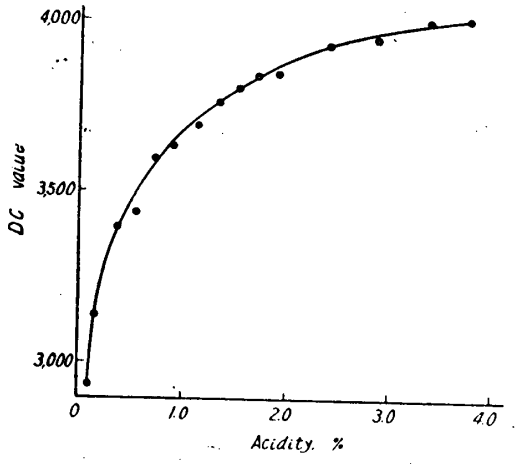

Fig. 3 Relation between DC and acidity

As shown in Fig. 5, W-B and T-B showed an outstanding decrease of total DC, which is caused by a high concentration of ethanol and a decrease of acidity. On the other hand, the color of To-B was not affected by ethanol concentration and acidity, since this beverage probably contained little of natural grape juice in addition to coloring with tar pigments. In the adjustment of ethanol concentration and acidity, the total DC showed a very small decrease with the progress of dilution (W-A and T-A). This may be due to that the proportion of malic acid in *Concord* grape juice is somewhat larger than that of tartaric.

From these facts it is deemed that pH is suitable rather than titratable acidity. However, the use of titratable acidity is possible in the case of natural grape juice which is thought to contain unchangeable kind of acids in almost constant proportion. In the case of marketed grape juices, further investigation for the finding of a suitable prepration method of the sample is necessary, for most of these beverages contain different acids and pigments from those

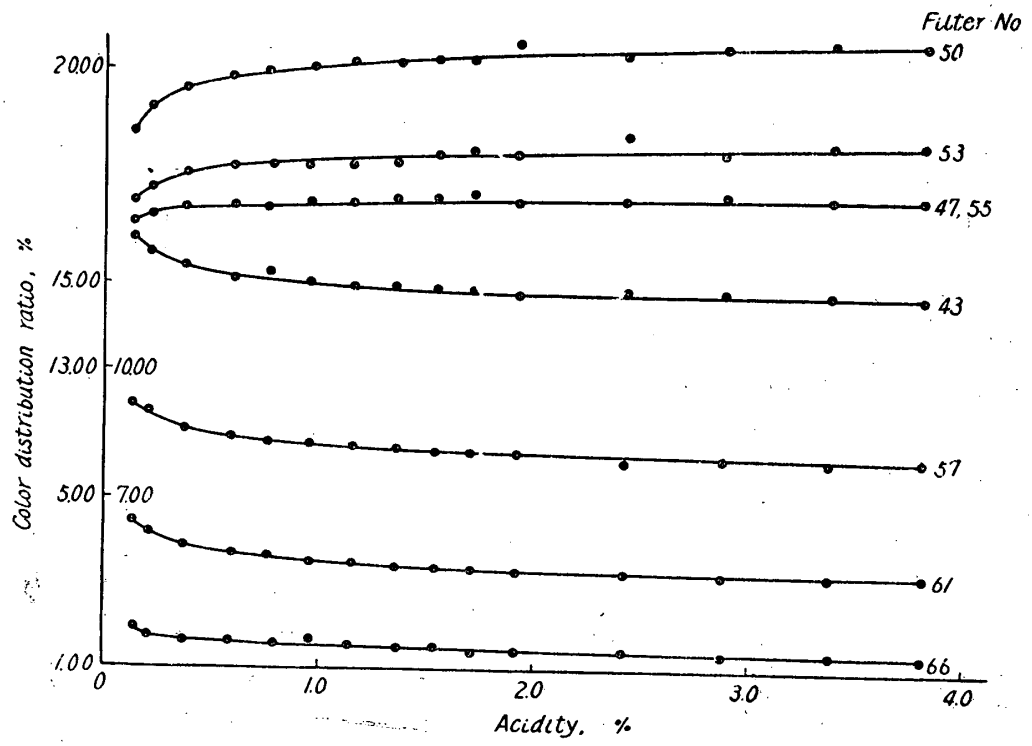

Fig. 4 Relation between color distribution ratio and acidity

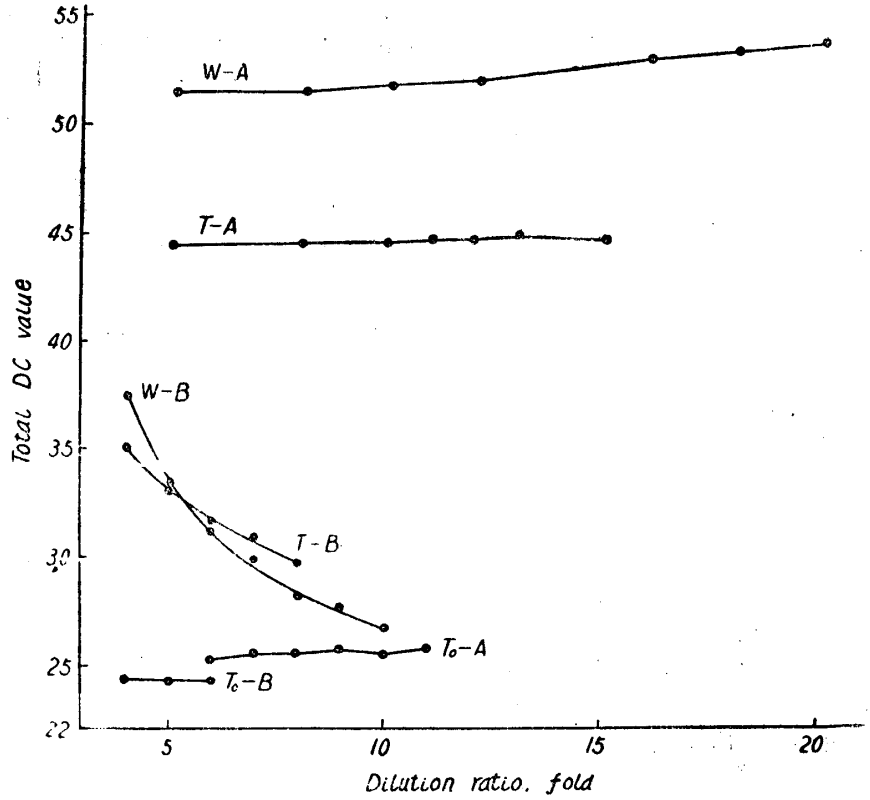

Fig. 5 Relation between total DC and dilution ratio

contained in natural grape.

To measure the color value in high accuracy with a spectrophotometer (in optical density range of 0.15 to 0.70 with Hitachi Spectrophotometer EPO-B), grape juice must be diluted. Measurement in the very high range of optical density, as made by Hozumi (5), can not give possibly the true absorption values.

From the reasons described hitherto, the preparation method of sample for color measurement of grape juice is made as follows, excepting the marketed juice :

(i) Prepare the acid solution, in which tartaric and malic acids are contained at 10 per cent, respectively.

(ii) Fix the suitable dilution ratio in the preliminary experiment.

(iii) Measure the titratable acidity of the juice.

(iv) Calculate from the dilution ratio the necessary volumes of water, acid solution and ethnal so that the acidity may be the same as the original juice and the ethanol concentration may be 50 per cent after dilution.

(v) Take a certain volume of juice in a 100ml Erlenmyer flask, and then add the calculated volumes of water, acid solution and ethanol, stop closely and stir vigorously and allow it to stand for cooling to room temperature.

(vi) Pour the above mixed solution into a precipitation bottle with a stopper,

centrifuge, and transfer the upper clear liquor into a test tube for color measurement.

[II] Comparison among Various Pressing Methods in the Production of Grape Juice

Using 7.5 kg of fully mature *Concord* grapes as raw material, the combination of cold- or hot-pressing and stemming or unstemming was examined as described below :

(1) Cold-pressing of unstemmed grapes : Unstemmed grapes were crushed and pressed without previous heating. Pomace was mixed with 3 *l* of boiling water and pressed after allowing to stand for 10 minutes.

(2) Cold-pressing of stemmed grapes : Procedures were the same as (1), except for stemming.

(3) Hot-pressing of unstemmed grapes : Unstemmed grapes were crushed and heated up to 60°C on the water bath, and then pressed after allowing to stand for 10 minutes. Pomace was mixed with 3 *l* of boiling water and pressed after allowing to stand for 10 minutes.

(4) Hot-pressing of stemmed grapes : Procedures were the same as (3), except for stemming.

Analyses of juice (first run juice) and pomace extract (second run juice) obtained by the above pressing methods are given in Table 2 and the yield of each component in Table 3.

The first run juice was bottled and pasteurized at 75°C for 30 minutes. Pomace extract was concentrated with the all-glass small scale evaporator (6) until argols crystallized on the inside wall of the evaporating tube, and then it was bottled and pasteurized at 75°C for 30 minutes. After pasteurization, the first run juice and pomace extract were stored at room temperature for 20 days and again analysed (Table 4). The analytical values to be equivalent to those of pasteurized pomace extract before concentration were obtained by calculation from the values shown in Table 4 and the concentration ratio based on sugar contents before and after concentration, and the results are shown in Table 5.

The following remarks are derived from the above described results.

(a) As known from Table 2, the acid content of cold-pressed juice is less than hot-pressed juice, which agrees with the previous result (4), while the pomace extract of cold-pressing is more acid than that of hot-pressing. Total sugar yield of the unstemming method is more than that of the stemming method (Table 3). In regard to sugar yield of the first run juice, the unstemming method of hot-pressing is more effective than the stemming one and the stemming method of cold-pressing is more effective than the unstemming one. This makes it clear that the sugar yield is closely connected with the volume of pressed juice. The acid content of the first run juice does not decrease by pasteurization, while pomace extract after pasteurization shows an acid decrease (Table 5), which

Table 2. Component of juice and pomace extract obtained by various pressing methods

		Reducing sugar %	Acid (as tartaric) %	Tannin mg%	pH	Balling	Total DC	Aroma a) strength	Juice volume l	
Cold-pressing of unstemmed grapes	First run juice	9.72	0·778	73.36	2.0	11.54	2.113	16	4.71	8.71
	Pomace extract	3.69	0.692	107.34	2.2	5.87	35.472	16	4.00	
Cold-pressing of stemmed grapes	First run juice	9.89	0.838	23.16	1.9	11.72	2.178	16	4.97	8.66
	Pomace extract	2.80	0.672	103.99	2.3	4.94	41.975	16	3.69	
Hot-pressing of unstemmed grapes	First run juice	9.82	1.175	116.09	2.0	12.81	54.975	64	5.60	8.75
	Pomace extract	2.40	0.317	61.79	2.4	3.50	9.880	6	3.15	
Hot-prossing of stemmed grapes	First run juice	9.55	1.160	97.82	2.0	12.42	49.635	32	5.02	8.45
	Pomace extract	2.71	0.374	66.15	2.4	4.12	13.840	8	3.43	

a) Number of aroma strength is experessed as maximum dilution degree of juice which produce the *Concord* aroma in organoleptical test.

Table 3. Yield of each component of juice and pomace extract obtained by various pressing methods

		Reducing sugar g		Acid g		Tannin g		Tatal DC × Juice Volume,l		Aroma strength × Juice Volume,l	
Cold-pressing of unstemmed grapes	First run juice	457.34	604.94	36.64	68.32	3.455	7.749	9.948	151.836	75.36	139.36
	Pomace extract	147.60		31.68		4.294		141.888		64.00	
Cold-pressing of stemmed grapes	First run juice	491.53	594.85	41.65	66.45	1.151	4.988	10.825	165.713	79.52	138.58
	Pomace extract	103.32		24.80		3.837		154.888		59.06	
Hot-pressing of unstemmed grapes	First run juice	549.92	647.20	65.80	75.79	6.501	8.447	307.860	338.982	358.40	377.30
	Pomace extract	97.10		9.99		1.946		31.122		18.90	
Hot-pressing of stemmed grapes	First runj uice	479.41	572.36	58.23	71.06	4.901	7.170	249.168	296.639	160.64	188.08
	Pomace extract	92.95		12.83		2.269		47.471		27.44	

Table 4. Component of juice and concentrated pomace extract after pasteurization

		Reducing sugar %	Acid (as tartaric) %	Tannin mg%	Total DC [a]	Aroma strength
Cold-pressing of unstemmed grapes	First run juice	—	0.786	15.96	1.878	16
	Concentrated pomace extract	11.47	2.031	327.41	114.195	8
Cold-pressing of stemmed grapes	First run juice	—	0.855	14.67	2.238	16
	Concentrated pomace extract	8.14	1.622	286.23	118.988	8
Hot-pressing of unstemmed grapes	First run juice	—	1.189	112.00	53.445	32
	Concentrated pomace extract	7.81	1.013	174.00	30.090	8
Hot-pressing of stemmed grapes	First run juice	—	1.190	96.27	46.815	32
	Concetrated pomacc extract	11.71	1.527	212.10	52.300	8

a) Total DC of concentrared pomace extract was measured at the aame acidity as before pasteurization.

Table 5. Component of original pomace extract after pasteurization[a]

	Acid (as tartaric) %	Tannin mg%	Total DC	Aroma strength
Cold-pressing of unstemmed grapes, Pomace extract	0.653	105.28	36.719	2.6
Cold-pressing of stemmed grapes, Pomace extract	0.557	98.36	40.889	2.7
Hot-pressing of unstemmed grapes, Pomace extract	0.312	53.54	9.258	2.1
Hot-pressing of unstemmed grapes, Pomace extract	0.353	49.10	12.106	2.4

a) Derived by calculation from the analytical values of concentrated pomace extract reported in Table 4.

may be perhaps caused by concentration rather than pasteurization.

(b) Tannin yield of the first run juice is remarkably affected by the difference of pressing methods, namely the hot-pressing gives far more tannin than the cold-pressing and the unstemming method gives more tannin than the stemming one (Table 3). However, in the second run juice (pomace extract) the difference of pressing methods has no important influence on tannin yield. In Japan, for commercial production of grape juice for drink the dilution method by blending of grape juice with sugar solution and pigments, etc. has been applied generally. Therefore, whether the stemming or unstemming method should be recommended depends upon the proportion of grape juice to be used. Hot-pressed juice and pomace extract do not undergo a noticeable change in tannin content by pasteurization, but tannin of cold-pressed juice shows a great decrease which must be due to its being pressed without previous heating.

(c) Cold-pressed juice is of light-color and not redish, or rather colorless. In yield of coloring matter (total DC × juice volume, *l*), cold-pressing is only about half as much as by hot-pressing. Of hot pressing, the unstemming method is somewhat more profitable in the yield of coloring matter than the stemming one. Decrease of color by pasteurization is 2.4 to 12.5 per cent in total DC. Argols crystallized during concentration are not thought to be responsible for the decrease in color. Color distribution ratio before pasteurization is shown in Table 6 and that after pasteurization in Table 7.

In cold-pressed juice, the absorption in filter No. 43 (wave-length range of 420 to 440 mμ) is highest and the absorption in longer wave-length range becomes low gradually. Hot-pressed juice has the highest absorption in filter No. 53 (wave-length range of 525 to 540 mμ). Cold-pressed juice after pas teurization shows a decrease of absorption in filter No. 43 and an increase in red range, but does not give the red color-sensation to the eye. On the contrary, hot-pressed juice after pasteurization shows an increase of absorption in filter No. 43 and a decrease in red range.

(d) Aroma and taste were organoleptically tested by four laboratory stuffs. Hot-pressed juice, especially from unstemmed grapes, is greater in aroma strength than cold-pressed juice. This relation is reverse in the case of pomace extract. The juice from unstemmed grapes gives the odor of the stem, regardless of whether it is hot-pressed or cold-pressed. Hot-pressed juice from unstemmed grapes is very astringent and that from stemmed grapes is mild. Aroma and taste are not essentially influenced by pasteurization, but the odor of the stem is remarkably decreased after pasteurization. Aroma of cold-pressed juice after pasteurization is unpleasant like before pasteurization. Aroma of pomace extract is also generally unpleasant but is improved to some extent by pasteurization, and strikingly decreased by concentration. The greater part of the aroma components is carried to the distillate during con-

Table 6. Color distribution ratio of juice and pomace extract before pasteurization

Filter No.		43	47	50	53	55	57	61	66
Cold-pressing of unstemmed grapes	First run juice	31.25	17.05	14.91	9.94	9.38	6.39	5.68	2.84
	Pomace extract	9.10	11.37	20.41	24.20	21.68	9.34	3.02	0.89
Cold-pressing of stemmed grapes	First run juice	30.58	17.63	16.53	10.33	9.37	6.61	6.20	2.75
	Pomace extract	8.36	11.31	20.84	24.46	22.11	9.45	2.73	0.76
Hot-pressing of unstemmed grapes	First run juice	8.73	11.60	21.83	24.56	21.83	8.73	2.18	0.55
	Pomace extract	9.72	11.64	19.74	22.77	21.26	10.32	3.54	1.01
Hot-pressing of stemmed grapes	First run juice	8.76	11.79	21.15	24.18	21.76	9.07	2.57	0.73
	Pomace extract	9.36	11.02	20.05	23.12	21.39	10.44	3.61	0.98

Table 7. Color distribution ratio of juice and pomace extract after pasteurization

Filter NO.		43	47	50	53	55	57	61	66
Cold-pressing of unstemmed grapes	First run juice	28.75	17.25	14.38	11.02	9.58	7.99	6.23	4.79
	Pomace extract	9.61	12.28	18.37	23.39	20.87	11.06	3.05	1.40
Cold-pressing of stemmed grapes	First run juice	28.55	17.43	14.61	10.99	9.65	8.04	6.17	4.56
	Pomace extract	9.06	12.07	18.51	23.59	21.18	11.31	2.98	1.32
Hot-pressing of unstemmed grapes	First run juice	9.23	12.69	19.51	23.29	20.63	10.61	2.89	1.15
	Pomace extract	9.87	12.16	17.59	22.18	20.65	12.01	3.94	1.61
Hot-pressing of stemmed grapes	First run juice	9.23	12.71	19.22	23.39	20.99	10.61	2.85	0.99
	Pomace extract	10.07	12.32	17.78	22.27	20.60	11.63	3.79	1.52

Table 8 Component of juice in each process of production-1

	Reducing sugar %	Acid (as tartaric) %	pH	Tannin mg %	Balling	Total DC	Aroma strength	Concentration ratio	Juice volume, l
Original juice	9.72	1.244	2.0	110.42	12.99	62.700	16 to 32	1.00	53.22
Deodorized juice	10.70	1.372	2.0	118.40	14.07	68.250	16	1.10	48.35
Concentrated juice a)	24.77	2.442	1.8	235.01	27.02	156.100	4	2.55	20.88
Concentrated juice b)	24.44	2.390	1.8	213.13	27.50	144.800	8 to 16		

Data for essence recovery in production-1

	Feed			Essence		
	Variety	Volume, l	Aroma d) strength	Volume, l	Yield, %	Aroma d) strength
1st Essence	Original juice	53.22	16 to 32	2.160	4.06	240
2nd Essence	Distillate	24.03	4	1.065	4.43	90
3rd Essence	Waste water in 2nd essence recovery			0.805	3.35	60

a) Before pasteurization b) 7 Days after pasteurization c) Concentration ratio and juice volume were calculated from the sugar contents of the original, deodorized and concentrated juices.

centration.

(e) On the whole, the cold-pressing followed by the pomace extraction with hot water is inferior to the general hot-pressing. The use of cold-pressed juice may be available for preparing the white grape juice (light-colored juice), but is meaningless for other purposes. In the hot-pressing, the unstemming method is advantageous for recovering the various components. If the proportion of grape juice to be used in the commercial juice production is large, the juice obtained from the stemmed grapes is rather recommended lest the astringent taste should be too strong. However, when fresh grapes are not easily obtained, the stemming method is desirable.

[III] Experimental Production of Grape Juice

As aforementioned, the previous experiment (1) gave unsatisfactory results owing to the bad quality of the raw fruits, the imperfection of essence recovery equipment and to our short-experience in operation. By overcoming these defects, this experiment gave, almost, the expected results. Production process is shown in Fig. 6, where Production Process I involves the hot-pressing of stemmed grapes and Production Process II the cold-pressing of unstemmed grapes. The concentration of juice was carried out below 36°C with the all-glass evaporator (1).

(1) *Production-1 : Hot-Pressing of Stemmed Grapes*

The fully ripened grapes (75 kg) was used as raw material within 24 hours after picking. The whole process was performed according to Production Process I, involving the press after allowing to stand for 15 minutes at 65°C. The pomace extracted with hot water did not give the highly colored juice, and therefore it was turned to waste. In the essence recovery, the waste water from

Table 9. Yield of each component in each process of production-1

	Acid g	Tannin g	Total DC× Juice volume,l	Aroma strength × Juice volume,l
Original juice	662.06	58.77	3336.89	851 to 1702
Deodorized juice	663.36	57.25	3299.89	774
Concentrated juice a)	509.89	49.07	3259.37	83
Concentrated juice b)	499.03	44.50	3023.42	167 to 334

Recovery ratio of each component in each process of production-1

	Acid, %	Tannin, %	RC
Original juice	100.00	100.00	1.00
Deodorized juice	100.20	97.41	0.989
Concentrated juice a)	77.02	83.50	0.977
Concentrated juice b)	75.38	75.73	0.906

a) Before pasteurization b) 7 Days after pasteurization

Table 10. Component of juice in each process of production-2

	Reducing sugar %	Acid (as tartaric) %	pH	Tannin mg%	Balling	Aroma strength	Total DC	Concentration ratio c)	Calculated juice volume, l	Observed juice volume, l
Original juice	8.59	1.410	2.1	73.10	11.98	16 to 32	13.390	1.00	30.22	30.22
Deodorized juice	10.82	1.638	2.1	90.09	13.81	8 to 16	19.928	1.26	23.98	23.25
Concentrated juice a)	27.52	3.419	1.8	186.36	30.25	8 to 16	59.080	3.20	9.44	8.70
Concentrated juice b)	27.35	3.348	1.8	190.64	30.28	-64 e)	53.784	—	—	—

a) Before pasteurization b) 7 Days after pasteurization c) Calculated from the sugar content. d) Calculated from concentration ratio. e) Negative value based on the cooked-odor.

the bottom of the rectifing column was again passed through the essence equipment because of the still remaining aroma, which was probably due to the operation without reboiler. The concentrated juice was allowed to stand at 0°C for 10 hours for the precipitation of argols, it was then centrifuged, bottled, and pasteurized at 75°C for 30 minutes.

Analysis of the juice in each stage of production process and data for the essence recovery are shown in Table 8. Yield and recovery ratio of each component in each stage of production process are shown in Table 9.

The following remarks are derived from these results.

(a) The amount of acid did not undergo a change in deodorization, but showed a decrease of 23 per cent by refrigeration after concentration and 1.6 per cent by pasteurization. Since argols crystallize remarkably on the inside wall of the evaporating tube in the concentration ratio of 2.5, the removal of argols must be carried out by refrigeration or other methods if concentration of higher degree is necessary.

(b) Decrease of tannin amount by deodorization, concentration, and pasteurization were 2.5, 14, and 8 per cent, respectively. The largest decrease is caused by concentration.

(c) Change of color was slight by deodorization and concentration but a decrease of 7 per cent in RC value was caused by pasteurization.

(d) The procedure of essence recovery was performed under the conditions of feed 20 *l* per hour and evaporation ratio 20 per cent. The essence yield reached to about 4 per cent as shown in Table 9, in spite of the aim at 1 to 2 per cent. Although the recovered essence itself was different from *Concord* aroma and rather similar to cooked-odor, the diluted essence did not have such a foul-odor and gave a close resemblance to *Concord* aroma.

(2) *Production-2 : Hot-Pressing of Stemmed Grapes*

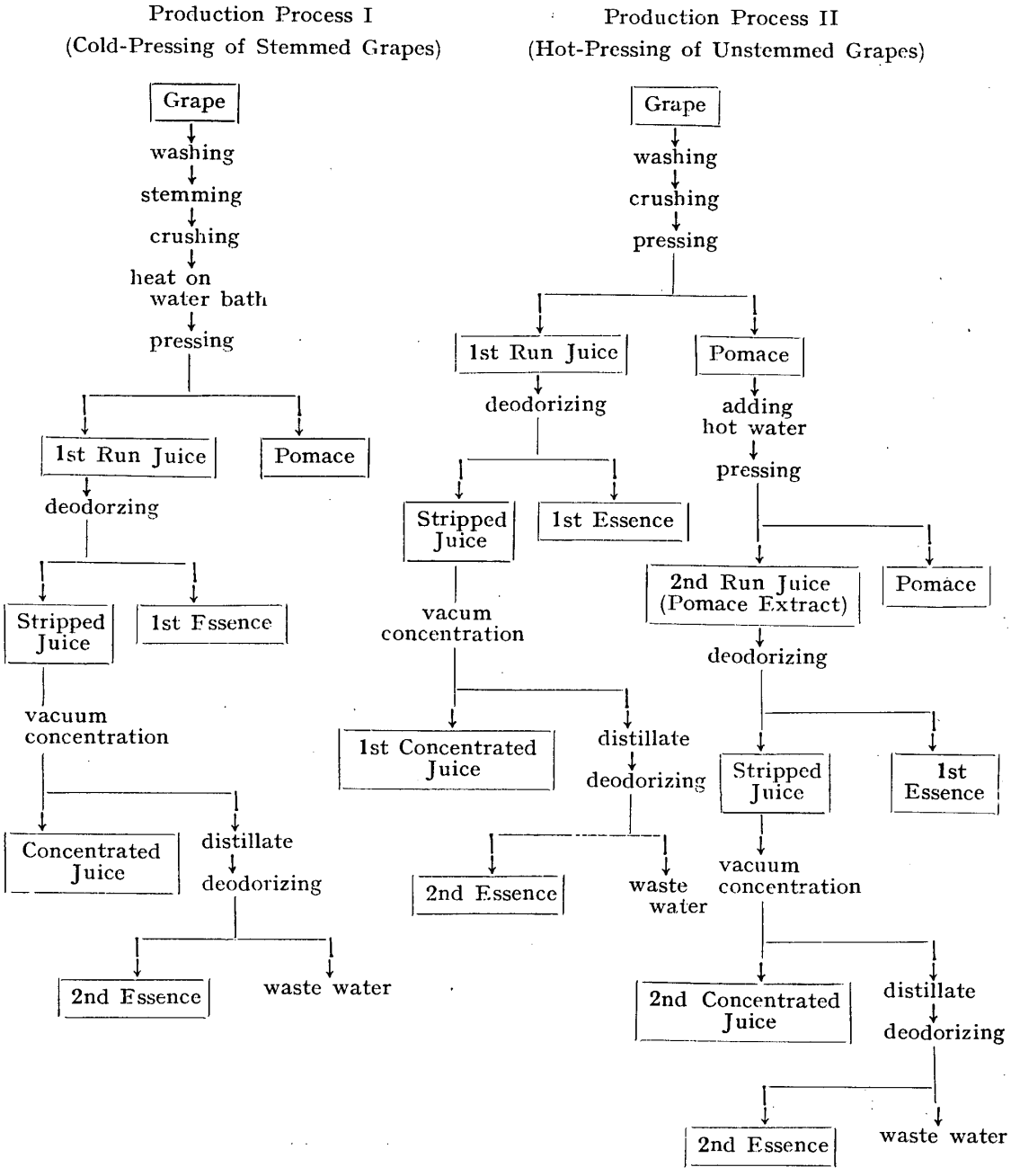

Fig. 6. Production process of grape juice

Grapes as raw material that were not fully ripened. The procedure was the same as that of Production-1, expcepting the waste water from the bottom of the rectifing column was mixed with the distillate obtained during concentration and again used for recovering the second essence because of the remaining aroma. Analysis of component of the juice in each stage of production process is shown in Table 10. The losses of juice in each stage of production process,

found from a comparison between the calculated juice volume based on analytical value and observed juice volume, were 3.04 per cent by deodorizing and 7.84 per cent by concentration. The loss by concentration is not due to only the juice adherent to the appratus but also to the crystallized argols. The yield of each component in each stage of production process is shown in Table 11.

It is noticed from Table 10 that the original juice contains less sugar, more acid, and less color than that obtained from fully ripened grapes in Production 1.

The change of each component in each stage of production process is as follows :

(a) The decrease of acid reached to 8 per cent by deodorization and 16 per cent by concentration, but pasteurization caused no outstanding change.

(b) The changes of tannin by deodorization and pasteurization were very little, but the decrease by concentration was 18 per cent.

(c) The increase of color was 16 per cent in total DC × juice volume by deodorization and 14 per cent by concentration. Although some decrease was caused by pasteurization, the pasteurized juice was still more in total DC × juice volume by 25.5 per cent than the original. Color distribution ratio, as shown in Table 12, underwent particular change by deodorization, namely the absorption was decreased in yellow and orange ranges, but increased in red range. It is not clear how such a change occurs. The remarkably high color value of concentrated juice is probably due to the composition of acids in grape juice, namely the proportion of malic acid is more than tartaric, and lower in pH than that of the original juice because the dilution ratio of concentrated

Table 11. Yield of each component in each process of production–2

	Acid g	Tannin g	Aroma strength × Juice volume, l	Total DC × Juice volume, l
Original juice	426.10	22.091	484 to 967	404.646
Deodorized juice	392.79	21.604	192 to 384	477.873
Concentrated juice a)	322.75	17.592	76 to 384	557.715
Concentrated juice b)	316.75	17.996	—	507.772

a) Befor pasteurization b) 7 Days after pasteurization.

Table 12. Color distribution ratio of juice in each process of production–2

Filter NO.	43	47	50	53	55	57	61	66
Original juice	15.81	16.17	19.60	19.60	16.11	8.18	2.98	1.55
Deodorized juice	12.26	13.93	20.23	22.14	18.69	9.05	2.57	1.14
Concentrated juice a)	11.66	14.21	19.98	22.29	18.99	8.84	2.67	1.35
Concentrated juice b)	13.08	14.66	19.36	21.14	18.17	9.01	3.04	1.54

a) Before pasteurization b) 7Days after pasteurzation

Table 13. Component of juice and pomace extract in each process of production-3

		Reducing sugar %	Acid (as tartaric) %	Tannin mg%	pH	Balling	Aroma strength	Total DC	Calculated juice volume, l
First run juice	Original	9.15	0.963	18.79	2.1	11.86	16 to 32	2.898	30.78
	Deodorized	11.41	1.184	18.28	2.1	14.52	4 to 8	3.336	24.62
	Concentrated a)	29.20	2.403	48.13	1.8	32.08	4	8.379	9.65
	Concentrated b)	29.20	2.404	41.18	1.8	—	16	7.214	9.65
Pomace extract	Original	2.54	0.404	105.53	2.6	4.49	16	36.800	21.48
	Deodorized	3.26	0.775	131.79	2.4	5.11	16	48.300	16.78
	Concentrated a)	13.20	2.218	484.92	2.0	17.57	4 to 8	159.060	4.13
	Concentrated b)	13.25	2.143	442.73	2.0	—	8 to 16	151.140	4.13

a) Before pasteurization b) 10 Days after pasteurization

juice is higher than the original.

(d) Recovery of essence was carried out in the condition of evaporation ratio 20.65 per cent. Yield and aroma strength of the first essence were 668 and 720ml, respectively. Those of the second essence were 452 and 360ml. Pressed juice had a green odor because the raw grapes were not ripe. The deodorized juice had no green odor but a slightly cooked-odor. The recovered essences were unpleasant as in Production-1, but such a foul-odor disappeared when those were diluted with water.

(3) *Production-3 : Cold-Pressing of Unstemmed Grapes*

The whole procedure was performed according to Production Process II. A considerable amount of the used grapes were injured during conveyance. Component of the juice in each stage of production process is shown in Table 13, the yield of each component in Table 14, and the color distribution ratio in Table 15.

It is known from these Tables that the changes of acid, tannin, and color have a tendency similar to the results of Production-1 and -2, and the color distribution ratio shows no unusual change through each stage of production process. Recovered essence having an unpleasant odor showed a resemblance to *Concord* aroma in the case of dilution with water.

[IV] Dicussion and Conclusion on Production of Grape Juice

(1) Grapes as raw material : The juice produced from not fully ripened grapes is weaker in *Concord* aroma, contains less sugar, more acid, and a weaker color. Aroma of juice from injured grapes also is not good.

Table 14. Yield of each component in each process of production-3

		Acid g	Tannin g	Aroma strength × Juice volume,l	Total DC × Juice volume,l
First run juice	Original	296.41	5.784	492 to 985	89.200
	Deodorized	291.50	4.501	98 to 197	82.132
	Concentrated a)	231.89	4.645	39	80.857
	Concentrated b)	231.99	3.974	154	69.615
Pomace extract	Original	133.39	22.668	344	790.464
	Deodorized	130.05	22.114	268	810.474
	Concentrated a)	91.60	20.027	16 to 33	656.918
	Concentrated b)	88.51	18.285	33 to 65	624.208

Data for essence recovery in production-3

		Volume, ml	Aroma strength	Aroma strength × Essence volume,l
First run juice	First essence	1367	90 to 180	120 to 240
	Second essence	970	90	87
Pomace extract	First essence	917	180 to 360	165 to 330
	Second essence	550	60	33

a) Before pasteruization b) 10 Days after pasteruization

Table 15. Color distribution ratio of juice and pomace extract in each process of production-3

Filter No.		43	47	50	53	55	57	61	66
First run juice	Original	28.49	19.67	15.53	11.18	9.63	7.35	4.97	3.21
	Deodorized	22.66	17.27	16.91	14.39	12.77	8.45	4.50	3.06
	Concentrated a)	22.91	17.57	16.54	14.32	12.60	8.52	4.69	2.86
	Concentrated b)	24.52	17.62	15.79	13.34	12.15	8.31	5.07	3.20
Pomace extract	Original	9.67	12.55	19.57	23.21	20.71	10.27	2.93	1.09
	Deodorized	9.50	12.61	19.25	22.98	20.99	10.43	2.98	1.24
	Concentrated a)	10.00	13.13	19.99	23.39	20.37	9.62	2.53	0.98
	Concentrated b)	9.81	12.82	19.02	23.03	20.64	10.44	3.02	1.23

a) Before pasteurization b) 10 Days after pasteurization

(2) Pressing method: Cold-pressing gives the juice having low content of various components and unpleasant odor. Hot-pressed juice from unstemmed grapes is high in content of each component. The odor of the stem from unstemmed grapes is improved by such a heating as pasteurization. In commercial juice production, therefore, hot-pressing of unstemmed grapes is recommended, but when fresh and fully ripened grapes are not obtained, the stemming method is desirable.

(3) Reocvery of essence: The evaporation of aroma components is imperfect even at 20 per cent of evaporation ratio and far more difficult than that of apple juice. The reboiler should be used in the bottom of the rectifing column since the waste water has a tendency to contain some amount of aroma. In the

ordinary procedure (7), recovery of essence has been made after argols of pasteurized juice have been removed by storage at room temperature or at 0°C for 2 to 6 months. However, this experiment without storage of juice gave satisfactory results. The juice stored at room temperature for 3 months after pasteurization is thought to lower in *Concord* aroma.

(4) Concentration : If argols are not removed by any method beforehand, the concentration ratio of juice can not exceed 2.5 to 3.0. The distillate collected during concentration contains a considerable amount of aroma components. Therefore, reocvery of the second essence from the distillate is the inevitable procedure. The concentration method involving the use of barometric condenser is meaningless so far as the second essence is required. However, if it is taken into consideration that the commercial grape juice production in Japan is generally by the blending method of grape juice with sugar solution, and that the loss of acid, tannin and color occur during concentration, it may be recommended that the preparation of concentrated grape juice is made suitable by the addition of sugar to the grape juice rather than by evaporation.

(5) Acid : The decrease of acid by deodorization and pasteurization is very small, while concentration causes a striking decrease which possibly reaches to 30 per cent. The experiment concerning the decrease of acid during the storage is now being continued.

(6) Tannin : The tannin decrease of cold-pressed juice is largely caused by such a heating as pasteurization, and that of hot-pressed by concentration.

(7) Color : Color of the cold-pressed juice is largely decreased by heating and that of hot-pressed juice by concentration. Changes of color distribution ratio by deodorization and concentration is slight. Pasteurization has a tendency to cause, somewhat, an increase of absorption in the yellow range and a decrease of absorption in the red range. It is generally said that crystallization of argols causes a change or decrease of color, but such phenomena have not occurred in this experiment, in which argols have been crystallized rapidly at about freezing point. The experiment to see the change of color during storage is also being carried on.

(8) Essence : Recovered essence has generally an unpleasant odor similar to cooked-odor, which in most cases disappears when it is diluted with water. The concentrated methyl anthranilate also gives such an odor. Hence, it is thoght that this unpleasant odor is not due to the cooked-odor but to the high concentration of aroma components. When methyl anthranilate is added to the deodorized grape juice, *Conocord* aroma is sufficientlly produced but the freshness is inferior to the natural grape essence. The unripe, injured or deteriorated grapes should not be, of course, used in the recovery of essence.

(9) Production Process : In the production of red grape juice from *Concord* grapes, it is the general procedure that the juice has been hot-pressed for the

full development of *Concord* color and aroma, and stored at low temperature for the precipitation of argols and other sediments, and afterwards deodorized and concentrated if necessary. However, in this experiment, the pressed juice has been deodorized and concentrated without previous storage. Argols of the concentrated juice can be precipitated in such a shorter time as few days. By concentration the juice volume is decreased, which is surely advantageous for the storgae and conveyance. Moreover, the concentrated juice will restrain the action of microorganisms because of the high content of acid and sugar. In this experiment, the concentration ratio was about 2, because pectic substances were not removed. The influence of pectolytic enzyme on clarification of grape juice will be examined at another opportunity.

As above-mentioned, acid and color are decreased by concentration. It is, therefore, supposed that the concentrated grape juice for drink is desirable to be prepared with the addition of sugar without evaporation. When the juice is hot-pressed for the developing of *Concord* color, recovery of essence and flash-evaporation will be effectively made in the utilization of heat energy of the pressed juice. The flash-evaporation effects to lower the temperature of the jucie and to decrease the volume of juice. If the flash-evaporated juice is mixed with sugar and recovered essence and then stored for removal of argols, it may be marketed as concentrated grape juice.

Summary

(1) From the stemmed or unstemmed *Concord* grapes harvested in Miyagi Prefecture, the grape juice was experimentally produced by means of cold- or hot-pressing, and the comparison among the various production methods was discussed from the standopints of sugar, acid, tannin, color, aroma and taste.

(2) It was found that the grape juice diluted for color measurement with a spectrophotometer should be clarified at fifty per cent of ethanol concentration and adjusted at the same acidity as the original juice, so that the deviation of measurement might be minimized.

(3) The essence recovery from juice could be well performed directly after pressing. No need of long-time storage was found before the essence recovery.

(4) Acid, tannin and color were decreased a little by deodorization and in a remarkable amount by concentration.

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