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Methods to Store Fruit Pulps in The Liquid State at The Frozen Storage Temperature

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과실 쥬스를 냉동저장온도에서 액체상태로 저장할수 있는 방법 연구

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Abstract

Combined cryoprotectants (C.C.) were formulated to depress freezing points of strawberry pulp and orange juice concentrate to −15°C, and quality changes in fruit pulps during storage at −15°C in the liquid state were investigated. C.C. suitable for strawberry pulp consisted of sucrose (25.5%, *w/w*), glucose (12.7%), fructose (12.7%), glycerol (1%), propylene glycol (1%) and ascorbic acid (0.1%), and that for orange juice concentrate containing 48% solids glucose (5%), fructose (5%), glycerol (4%) and citric acid (1%). When quality of fruit pulps was compared among control and those with C.C., quality of fruit pulps stored with added C.C. was at least as good as control, except treatment B which had significantly lower overall preference. Strawberry jam prepared from pulp stored for 4 monthes did not show any significant quality differences among control and treated samples. The results of this study indicated that fruit pulps could be stored with added C.C. in the liquid state at the frozen storage temperature, while maintaining qualities at least as good as the conventionally frozen stored products.

Introduction

Changes in texture and degradation of food componets are the main quality changes in frozen products. Texture changes in frozen foods occur mainly due to phase changes of water to ice crystals in freezing process and ice crystals to water in thawing process, and texture changes in frozen foods and serious quality problems in solid and liquid foods. Thawing frozen fruit juices, milk, egg and emulsion systems often results in separation of emulsion and gelation due to denaturation of proteins, and these changes seriously affect appearance or utility value of the products (Chien et al., 1966; Winder, 1962).

Cryoprotectants are used to minimize texture destruction of frozen foods or to prevent loss of vitality of organisms during frozen storage. Mono-and disaccharides (Desai et al., 1961), poly alcohol (Love and Elerian, 1965) and inorganic salts (Coriell et al., 1964) are utilized as cryoprotectants, which have functions of maintaining emulsion stability, minimizing protein denaturation and enhancing small ice crystal formation. Merryman (1970) indicated that addition of cryoprotectants to liquid foods depressed freezing points and minimized texture changes.

An attempt was made in this study to store liquid foods in unfrozen state at the frozen storage temperature by depressing freezing points of liquid foods with added cryoprotectants. The advantages of this treatment would be to minimize texture changes of food products and to reduce energy requirement for storage of food products at frozen storage temperature by eliminating phase changes of water to ice or vice versa. The objectives of this study were to formulate suitable C.C. for depressing freezing points of fruit pulps to −15°C at which pulps could be stored in liquid state, to study qulity changes during storage of fruit pulps with C.C. in liquid state at −15°C, and to evaluate quality of fruit jam prepared from stored fruit pulps with C.C.

Material and Methods

Fruit pulps and cryoprotectants

Strawberry pulp and orange juice were selected as

models of fruit pulps in this study. Strawberry pulp was prepared from strawberry purchased from the market in 1984. Oranage juice concentrate containing 62% solids was prepared in 1984 using a APV pilot concentrator.

Cryoprotectants screened for formulation of C.C. were sucrose, glucose, fructose, glycerol, propylene glycol, citric acid and ascorbic acid.

Formulation of C.C.

Selection of cryoprotectants for formulation of C.C. was based on sugar composition of fruit pulp, flavor quality of fruit pulp after adding C.C. and final use of the pulp after storage. A suitable C.C. for each fruit pulp was selected from several possible formulas.

Freezing points of fruit pulps with increasing concentration of C.C. were determined from the freezing curve using copper-constantan thermocouples and a temperature recorder. Optimum concentration of C.C. required to depress freezing point to −15°C was obtained from the freezing point curve.

Storage of furit pulps with C.C.

Straberry pulp and orange juice concentrate were stored by the following methods to study quality changes in fruit pulps with C.C. during storage.

Strawbery pulp;

Control — Pulp (75%) was mixed with sucrose (25%) and stored at −18°C.

Treatment A — Pulp was mixed with C.C. and stored at −15°C.

Treatment B — Pulp heated to 70°C for 5 min. was mixed with C.C. and stored at −15°C.

Crange juice concentrate;

Control — Juice with 62% solids was stored at −18°C.

Treatment C — Diluted juice with 36% solids was mixed with C.C. and stored at −15°C.

Treatment D — Diluted juice with 48% solids was mixed with C.C. and stored at −15°C.

Determination of quality changes during storage

Fruit pulp samples were taken at 2—3 week intervals during storage tests and quality changes were evaluated by the following methods.

Retention of ascorbic acid:

Ascorbic acid contents was determined by the liquid chromatographic method reported Haney et al. (1976). The filterate of samples was injected to the liquid chromatograph (Waters Associates, Model 440) and ascorbic acid was detected at 254 *nm*.

Consistency:

Consistency of fruit pulps was measured by Brookfield Viscometer (model LVT). Spindle No. 2 was immersed in fruit pulps at 36°C and consistency was read after 5 *min*. of rotation at 30 rpm.

Surface color:

Surface color was measured by Color and Color Difference Meter (model UC600-IV, Yasuda Seiki Seisackusho Ltd.).

Overall preference:

Overall preference of stored samples was evaluated by 15 panel members using 9 points hedonic scale.

Firmness of jam:

Firmness of fruit jam prepared from pulps store for 4 monthes with C.C. was measured by Instron (model TM 1140). Sample (height 30*mm*) was compressed with a plunger (dia 20*mm*) at a speed of 100*m/min* and peaks were recorded on the chart (chart speed 100*mm/min*).

Preparation of strawberry jam

Strawberry jam was prepared from 4 monthes stored pulps. After 0.2%(*w/w*) citric acid and 0.7% pectin were added to pulp, the mixture was concentrated to 65% solids.

Results and Discussion

C.C. to depress freezing point to −15°C

Among the possible formulas of C.C. to depress freezing points of fruit pulps, the following C.C. were selected as the most acceptable ones in terms of flavor quality and freezing point depression (Table 1).

When increasing concentration of sucrose, glucose, and fructose at a ratio of 2:1:1 was added to strawberry pulp with 1% glycerol, 1% propylene glycol and 0.1% ascorbic acid, freezing point of pulp was lowered as shown in Figure 1. When 53% of C.C. was added to strawbery pulp, freezing point of the pulp was depressed to −15°C. Optimum concentration of C.C. required to depress freezing points of orange juice concentrate to −15°C were determined by the same method. The results showed that

Table 1. Formulas of C.C. suitable for fruit pulps

Constituents of C.C.	Strawberry pulp	Orange juice concentrate	
		36% solids	48% solids
sucrose	25.5%	—	—
glucose	12.7	12%	5%
fructose	12.7	12	5
glycerol	1	4	4
propylene glycol	1	—	—
ascorbic acid	0.1	—	—
citric acid	—	1	1
Total	53%	29%	15%

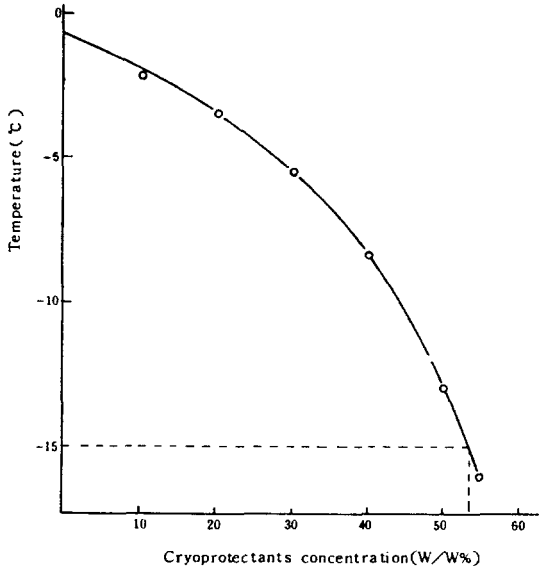

Fig. 1. Freezing point depression of strawberry pulp as affected by concentration of C.C

29% and 15% of C.C. were required to depress freezing points of orange juice with 36% and 48% solids, respectively.

Heiss and Schachinger (1951) and Deshpande (1982) reported that freezing point depression of fruit juices and other liquid foods depended upon composition of the product, especially sugars, acids and inorganic compounds. Protein and fat in foods and minimum effet on freezing point depression.

Retention of ascorbic acid in stored fruit pulps

Changes in % retention of ascorbic acid in strawberry pulp and orange juice concentrate during storage was shown in Tables 2 and 3. In general, % retention of ascorbic acid in fruit pulps decreased as the storage period was extended. There were no significant differences in average values of % retention of ascorbic acid among control and treatments of strawberry pulp and orange juice concentrate.

Changes in consistency and surface color of strawberry pulp

Consistency of strawberry pulp samples taken at various storage times was measured after adjusting sugar contents of control to he level of treatment A, and the results are given in Table 4.

Consistency of all strawberry pulp samples decreased as storage period was extended. Average consistency

Table 2. Retention of ascorbic acid in stored strawberry pulp

Storage period (weeks)	Control	Treatment A	Treatment B
0	100%	100%	100%
3	99.3	98.9	98.3
6	96.3	97.1	95.9
9	93.5	94.1	93.7
12	93.3	94.1	91.2
15	89.6	90.4	88.5
18	90.0	89.9	88.6
Average	94.6	94.5	93.7

Table 3. Retention of ascorbic acid in stored orange juice

Storage period (weeks)	Control	Treatment A	Treatment B
0	100%	100%	100%
2	99.2	98.1	99.4
4	97.5	97.9	98.5
6	96.5	97.7	98.2
8	95.1	97.4	97.2
10	94.6	95.9	96.5
12	94.4	95.4	96.6
14	94.0	95.3	95.1
16	94.0	95.6	94.6
Average	96.1	97.0	97.3

Table 4. Changes in consistency of strawberry pulp during storage

Storage period (weeks)	Control	Treatment A	Treatment B
0	631 cps	572 cps	480 cps
3	615	534	429
6	612	530	416
9	600	538	409
12	595	520	400
15	581	514	405
18	576	503	395
Average	601	530	419

values of control and treatment A were not significantly different each other.

But treatment B had significantly lower average consistency than control and treatment A. The low consistency of treatment B might be due to heat treatment of the pulp prior to storage, although direct evidence to explain it was not available.

In case of surface color, 'a' value which indicated redness of the sample did not change markedly in all samples during storage. However, treatment B had significantly higher 'a' value than control and treatment A. This could be due to heat inactivation of enzymes in strawberry pulp which were involved in degradation of red pigments. The total color difference, ΔE, generally increased in all samples during storage.

Overall preference of fruit pulps

Overall preference of stored fruit pulps evaluated by 15 panel members using 9 points hedonic scale are shown in Tables 6 and 7. In strawberry pulps, sugar contents of control was adjusted to the level of treatment A for sensory evaluation, and orange juice concentrates were diluted to the single fold (12% soluble solis) and sugar contents was adjusted to the level of treatment C for sensory evaluation.

Average overall preference of treatment B was significantly lower than that of control and treatment A, while there was no significant difference in average preference values between control and treatment A. In case of orange juice concentrate, there was no significant difference in average preference values among 3 samples. Significant low preference of treatment B could be due to flavor loss by heat treatment prior to storage.

Quality changes in strawberry jam during storage

Table 5. Changes in surface color of strawberry pulp during storage

Storage period (weeks)	Control		Treatment A		Treatment B	
	a	ΔE	a	ΔE	a	ΔE
0	10.5	—	10.9	—	11.6	—
3	10.3	0.60	10.8	0.23	12.0	0.50
6	10.0	1.05	11.0	0.23	11.9	0.43
9	10.1	0.61	10.6	0.63	11.6	0.83
12	10.2	1.18	10.3	0.82	11.5	0.55
15	10.3	1.48	10.7	1.19	11.4	0.28
18	10.2	1.51	10.4	0.92	11.4	0.82
Average	10.2	1.07	10.7	0.67	11.6	0.57

Table 6. Overall preference of strawberry pulps evaluated by 9 points hedonic scale

Storage period (weeks)	Control	Treatment A	Treatment B
0	6.4	6.9	6.5
3	6.3	6.0	5.6
6	6.8	6.3	6.0
9	6.8	6.5	5.7
12	6.7	6.7	5.8
15	6.6	6.6	5.2
18	6.5	6.7	5.4
Average	6.6	6.5	5.7

Table 7. Overall perference of orange juice evaluated by 9 points hedonic scale

Storage period (weeks)	Control	Treatment A (36% solids)	Treatment B (48% solids)
4	6.2	6.6	6.3
8	6.6	6.4	6.2
12	5.8	5.8	6.1
16	5.6	5.6	6.2
Average	6.1	6.1	6.2

Strawberry jam prepared from pulp stored for 4 monthes was stored at 20°C, and changes in surface color and firmness of jam during storage were evaluated.

Redness (a value) of strawberry jam did not change markedly during stoage in all samples. Average 'a' values of treatment A and B were significantly higher than that of control (Table 8). Firmness of strawberry jam increased in all samples as the storage period was extended. Treatment A had significantly higher firmness and control significantly lower firmness than the rest of samples (Table 9).

Overall preference of strawberry jam was evaluated by 15 panel members using 9 points hedonic scale, and the results are contained in Table 10. Average values of overall preference were not markedly differnet among 3 samples. The results of sensory test indicated that higher 'a' value and higher hardness observed in treatment A and B(Tables 8 and 9) did not affect on overall preference of strawberry jam.

Table 8. Changes in surface color of strawberry jam during storage

Storage period (weeks)	Control		Treatment A		Treatment B	
	a	ΔE	a	ΔE	a	ΔE
0	7.5	—	8.4	—	8.8	—
4	7.8	0.66	8.5	0.89	8.5	1.03
8	7.2	0.35	7.9	0.70	8.4	1.17
12	7.0	0.64	8.4	1.29	9.1	0.74
16	7.2	0.45	9.0	1.26	9.1	0.92
Average	7.3	0.53	8.4	1.04	8.8	0.97

Table 9. Firmness of strawberry jam measured by Instron

Storage period (weeks)	Control	Treatment A	Treatment B
4	337g	337g	430g
8	340	465	420
12	345	535	423
16	401	575	551
Average	356	513	456

Table 10. Overall preference of strawberry jam evaluated by 9 points hedonic scale

Storage period (weeks)	Control	Treatment A	Treatment B
0	6.7	6.8	6.6
4	7.2	6.8	6.8
8	6.5	6.8	6.6
12	6.3	6.9	6.5
16	6.1	6.9	6.3
Average	6.6	6.8	6.6

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요 약

딸기쥬스와 오렌지쥬스 농축액의 빙점을 −15℃로 강하시킬수 있는 복합cryoprotectants를 선정하고, 이를 쥬스에 첨가하여 액체상태로 −15℃에서 저장하면서 품질변화를 조사하였다. 딸기쥬스에 적합한 복합 cryprotectants의 조성은 설탕25.5%(*w*/*w*), 포도당 12.7%, glycerol 1%, propylene glycol 1% 및 ascorbic acid 0.1%였다. 그리고 48% 고형분을 함유하는 농축 오렌지쥬스에 적합한 것으로는 포도당 5%, 과당 5%, glycerol 4% 및 citricacid 1%였다. 저장중 과실쥬스의 종합적 품질은 복합 cryoprotectants를 첨가한 것과 대조구사이에 차이가 없었고, 4개월 저장한 딸기쥬스로 만들은잼의 품질에 있어서도 대조구와 처리구간에 유의성 있는 품질차이가 없었다. 이들 결과로 보아 과실쥬스에 복합 cryoprotectants를 첨가하여 냉동온도에서 액체상태로 저장하면 보통 방법으로 냉동저장한것과 대등한 품질을 보존할수 있는 것으로 밝혀졌다.

References

1. Chien, H.C., Richardson, T. and Amundson, C.H.: *J. Dairy Res.*, **33**, 217 (1966)
2. Winder, W.C.: *J. Dairy Sci.*, **45**, 1042 (1962)
3. Desai, I.D., Nickerson, T.A. and Jennings, W.G.: *J. Dairy Sci.*, **44**, 215 (1961)
4. Love, R.M. and Elerian, M.K.: *J. Sci. Food Agr.*, **16**, 65 (1965)
5. Coriell, L.L., Greene, A.E. and Silver, R.K.: *Cryobiology*, **1**, 72 (1964)
6. Meryman, H.T.: *The Frozen Cell*, J and A Churchill London (1970)
7. Haney, W.G., Sood, S.P., Sartori, L.E. and Wittmer, D.P.: *Anal. Chem.*, **48**, 796 (1976)
8. Hiss, R. and Schachinger, L.: *Food Tech.*, **5**, 211 (1951)
9. Deshpande, S.S., Bolin, H.R. and Salunkhe, D.K.: *Food Tech.*, **3**, 68 (1982)

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