
University of Vermont and State Agricultural College
Vermont Agricultural Experiment Station
BURLINGTON, VERMONT

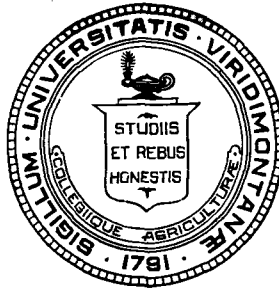
THE STORAGE OF PACKAGED ICE CREAM

By RICHARD W. SMITH, Jr.

Dhananjayrao Gadgil Library



GIPE-PUNE-047020



47020

Vanilla, strawberry, chocolate and maple walnut ice creams in quart and pint packages were placed in cold storage at from -6 to -20° F. for from 16 to 24 weeks and judged from time to time as to changes in weight, volume, body, texture and flavor.

Weight, volume, body and texture were not altered.

Surface film developed in unlined but not in lined packages in from three to four months' time.

Flavor began to deteriorate in the strawberry in from one to two months and in the vanilla in about three months, whereas the flavor of the chocolate and maple walnut ice creams remained unimpaired at the end of four months.

The true age of an ice cream is measured by the age or condition of the ingredients of which it is made rather than by the length of time since it was last frozen. Ice cream must be good to begin with or successful storage is impossible.

BULLETIN 394: THE STORAGE OF PACKAGED ICE CREAM

By RICHARD W. SMITH, JR.

INTRODUCTION

The ice cream business is a variable one tending to extreme fluctuations. This condition makes the sales and turnover of the manufacturer highly uncertain and difficult to anticipate. It may and often does become necessary to hold the finished product in the hardening rooms for several weeks. It is generally agreed that a direct relation exists between the age of ice cream and its quality. Considerable research has been done and much has been written on the subject, but in most cases emphasis has been placed on the effect of aging in the dealer's cabinet rather than in the manufacturer's hardening room.

Bayer (1) reported that in iceless cabinets vanilla ice cream changed appreciably in quality in 23, chocolate in 48 and strawberry in 13 days. The quality of check samples of the first two held in a hardening room remained unimpaired for 48 days while the latter's flavor changed in 13 days. He states further that ice creams deteriorated rather readily when other fruit and so-called special flavors were used.

Dahle and Folkers (3), scoring several hundred samples of vanilla ice cream held for two months, found that no "cardboard" flavor developed when dry skimmilks were used in the mixing formulas but that it did occur in most samples containing condensed skimmilk.

Schricker (7) discovered a direct relationship existing between age and quality and stated that the more old packages one has on hand the greater the likelihood that their contents will exhibit poor flavor. He found a few cases of shrinkage from the sides of the carton, but the body of the ice cream was good in most of the long-held packages. The strawberry goods deteriorated most rapidly.

Scism (8) made a detailed study of the relation of age and temperature to the physical qualities of sundry ice creams and found that vanilla samples, held in a hardening room at approximately -25° F., resisted deterioration remarkably well, no noticeable change being detected during the first five weeks of storage. In six weeks the body showed slight lack of resistance but it was not seriously affected even at the end of a 12-weeks period. The texture was criticised as "slightly open" after seven weeks and thereafter gradually deteriorated. A

slight development of "sandiness" was indicated in the final scoring at 12 weeks. On the other hand samples held in the mechanical cabinet were considerably impaired in body and texture at the end of two weeks, being "slightly coarse" and "slightly open." A stale flavor was noticed at four weeks, and at the end of six weeks the samples were scored as "coarse, lacking in resistance, open, stale and unsalable." Sandiness appeared by the eleventh and was quite pronounced by the twelfth week. The strawberry goods, held in the hardening room, lacked typical freshness at the end of four weeks and after six weeks were described as "flat" and wanting in character. The most noticeable change in flavor seemed to be the diminution in freshness which became manifest after three weeks of storage. Some tendency to coarseness was noticed at the end of 7 and sandiness developed in 12 weeks. The cabinet samples, as in the case of the vanilla, showed a more rapid deterioration, the delicate fresh strawberry flavor being largely lost in one and completely so in two weeks. After four weeks the sample was scored as "very open, sandy, coarse, and unsalable." Chocolate resisted impairment better than either vanilla or strawberry creams. The hardening room samples kept well until six weeks had elapsed when some lack of resistance was apparent. A little strong flavor developed during the eighth week but did not become objectionable even after 12 weeks. The cabinet samples showed a slight coarseness in four weeks, which was pronounced in six weeks, a bitter flavor developing after seven weeks, the goods becoming sandy and unsalable at the end of the 12-weeks period. The writer placed the maximum storage period in hardening rooms at four to six weeks.

Tracy, Ramsey and Ruehe (10), studying the causes of a stale metallic flavor in strawberry ice cream, report that when the mix was not contaminated with copper, this trouble did not develop after 40 days of storage in a hardening room at 0 to -10° F., but that when copper was present it was usually observed within 3 to 10 days. They also found that when 15 percent or more fruit was used and no copper contamination existed off-flavor did not develop in 77 days, whereas when 10 percent or less fruit was used a stale metallic flavor was noticeable at the end of 17 days.

Ross (6) is not in complete agreement with other investigators when he states that the fruit is not responsible for the off-flavors usually associated with strawberry ice cream. He found that control samples containing no strawberries stored for four weeks usually developed off-flavors before their companion strawberry samples made simultaneously

from the same mix. This would tend to indicate that such flavor defects may appear in any kind of ice cream and be more or less covered up by the flavoring materials used. He holds that copper contamination in condensed skimmilk, in conjunction with oxidation of its fat content which may occur during its manufacture and storage, may be at fault. He believes that the fat of the condensed skimmilk is carried practically through the induction period of oxidation before it is used in the mix and that relatively little further oxidation need occur after the ice cream is made as a precedent to the development of undesirable flavors.

Sommer (9) says that prolonged aging is not necessarily required to bring about undesirable changes in the flavor of dairy products that are contaminated with iron or copper. He states further that a characteristic stale flavor is occasionally found in strawberry ice cream in about two weeks. He believes that if ice cream is to be stored in the hardening room for some time its temperature should be kept as constant as possible in order to maintain good texture, steadiness being more vital than extreme cold, although both are important. The contents of retailers' cabinets are subject to many great temperature fluctuations and hence become much coarser in texture.

Tracy and Ruehe (11) report that the use of certain types of "improvers" may cause ice cream to shrink in volume. The factors which tend to hasten this shrinkage under such circumstances are: (a) alternating high and low temperatures; (b) long storage periods; (c) high percentage of overrun; (d) increased acidity; (e) high percentage of milk-solids-not-fat or increased concentration of these solids in the water of the mix.

Lucas and Merrill (5) found no diminution in the strength of vanilla flavor in ice cream stored for three months. Slight oxidation of the butterfat could be noted after a month's storage but this did not seem to affect the strength of the flavor.

Cole (2) states that although the vanilla flavor has been criticized as "freezing out" this lapse does not always occur, commercial reports to the contrary notwithstanding. He suggests that the stale flavors which frequently develop in stored ice cream may mask the vanilla flavor thus causing only an apparent decrease.

Ellenberger (4), in his study of bacteria in ice cream during storage, concludes that no radical change occurs in their total numbers. There seemed to be a tendency toward a slight decrease during the first two to four days, with a more noticeable increase and then a correspond-

ing decrease between the fourth and the twenty-first day, after which there was a gradual lessening in their numbers. These results would seem to indicate that deterioration in flavor is not apt to be due to bacterial contamination.

A recent publication issued by the International Association of Ice Cream Manufacturers presented figures showing monthly production in percentages over a 14-year period, as follows: January 3.71, February 4.02, March 5.46, April 7.38, May 11.03, June 14.47, July 16.25, August 13.92, September 9.88, October 5.96, November 4.23, December 3.69. Over four times as much is made in July as in December or January, as much as is made from November 1 to March 1. This situation presents a difficult problem to manufacturers in the handling of plant equipment and labor. Obviously if ice cream could be stored for considerable periods of time without quality deterioration, thus flattening out the peak of production, this problem would be a less serious one. Since little data are available touching the effect of package storage on quality, trials were instituted as to the relation of the length of the storage period changes to: (1) Weight, (2) volume, (3) body and texture, (4) flavor.

PROCEDURE

Ten batches each of vanilla, chocolate, strawberry and maple walnut ice creams were made, five in the University dairy laboratory and five in a commercial plant. The mix ingredients used were as follows:

MIX INGREDIENTS

Batch number	Fat percentages	Total solid percentages	Flavor	Cream*	Butter	Milk	Skim powder	Condensed milk§	Skimmilk	"Re-run"	Sugar	Egg	Gelatin	Neutralizer (soda)	Chocolate
	%	%		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
University dairy laboratory															
I	14	39.5	V., St., Ch., Hap.	32.26	...	48.09†	4.15	...	...	...	15	..	½	..	...
II-V	14	39.5	V., St., Ch., Hap.	30.	...	50.35‡	4.15	...	...	...	15	..	½	..	...
Commercial plant															
I	14	39.	V., Map.	1,395	104	...	...	706	1,622	62	705	..	18	½	...
	14	39.	St.	1,612	...	...	...	706	1,509	89	705	..	18	½	...
	12	42.78	Ch.	899	...	...	...	550	1,298	320	692	11	13	½	181
II	14	39.39	V., St., Map.	1,604	...	...	...	706	1,517	87	705	..	18	½	...
	12	41.46	Ch.	899	...	...	...	550	1,298	351	692	11	13	½	184
III	14	39.	V., Map.	1,376	116	...	...	706	1,629	19	705	..	18	½	...
	14	39.	St.	1,604	...	...	...	706	1,517	39	705	..	18	½	...
	12	41.46	Ch.	822	65	...	...	550	1,538	89	646	11	13	½	149
IV	14	38.68	V., St., Map.	1,624	...	...	...	706	1,497	73	705	..	18	½	...
	12	44.53	Ch.	534	...	...	...	404	631	112	391	5	7	..	93
V	14	31.	V., St., Map.	1,614	...	...	...	706	1,507	56	705	..	18	½	...
	12	43.68	Ch.	818	77	...	...	808	1,337	149	769	10	14	½	185

* Always 40% fat, except University batch I, 37%. † 4.3% fat. ‡ 4% fat. § 30% total solids.

The mixes made at the University plant were pasteurized in a glass-lined vat at 142° F. for 30 minutes, homogenized in two stages, 2,500 pounds on the first and 500 pounds on the second valve, cooled over a surface cooler to approximately 40° F., and aged in 40-quart cans in a cold room held at 42° F. for from 12 to 15 hours. The temperature of the mixes at freezing was approximately 45° F., freezing being done in a 40-quart direct expansion batch machine. The product was drawn at 80 percent overrun and packaged with a Bergman hand filler in standard round, tall quart and pint containers. Hardening and holding was done in an automatically controlled hardening room at -6° F. Four quarts of cold pack fruit were used in each batch of strawberry ice cream; the chocolate goods were flavored with a syrup made up of a small amount of mix to which two pounds of cocoa and one and one-half pounds of sugar were added and properly processed; two pounds of walnuts were added to each batch of maple walnut. All ingredients were of high grade.

The commercial plant mixes were made in stainless steel coil vats, pasteurized at 150° F. for 30 minutes, homogenized at 3,500 pounds pressure through one homogenizing valve followed by passage through a pressure reducing valve at an estimated pressure of about 500 pounds, cooled over a surface cooler to about 32° F. and aged in vats for 12 to 15 hours. Freezing was done in Vogt continuous freezers and fruit and nuts added with a fruit injector. Packaging was by hand direct from the freezer in lined quart and pint brick cartons. The hardening room was held at from -15° to -20° F. Ingredient quality was high and the fresh frozen product was considered very good.

The same general procedure was followed in all 10 batches, the mix being made one day, frozen and packaged the next, and hardened overnight. In most cases 13 quarts and 13 pints of each flavor, and in others 12 or 14, were withdrawn from cold storage the day after each batch was frozen, marked, carefully weighed on a balance sensitive to 0.5 gram and then replaced in cold storage and held there. Eight days after each batch was frozen a single quart and a single pint package representing each flavor were withdrawn from cold storage, reweighed and the contents critically examined as to flavor, body and texture. Similar data were gathered at weekly intervals thereafter until June 21 and then at biweekly intervals until the close of the trials. Flavor, body and texture were compared by three experienced judges.¹

¹ The writer is deeply appreciative of the courteous and efficient cooperation of his associate, Prof. J. A. Newlander, Station Assistant Animal and Dairy Husbandman and of Mr. John A. Buchanan, a graduate of the College of Agriculture in the class of 1933, who assisted him in the work of judging.

DISCUSSION

The numbers of weights taken at successive weighing dates were as follows:

University laboratory 8, 15*, 24, 32, 40, 40, 40, 40, 40, 40, 39*, 39*, 31*, 30**, 15*, 8. Total 520, lost 8 (as indicated by *). Initial total 528.

Commercial plant 8, 16, 16, 24, 24, 32, 40, 40, 40, 40, 40, 40, 40, 23*, 23*, 15*, 15*. Total 516, lost 4 (as indicated by *). Initial total 520.

All told 2,084 weights were made. The following table sets forth essential facts as to time limits:

Batch number	I	II	III	IV	V
University dairy laboratory					
Batch frozen on....	4/10	4/17	4/24	5/1	5/8
Successive weights from	4/18-8/2	4/26-8/30	5/2-8/30	5/9-9/13	5/16-9/28
Maximum age, days	114	135	128	135	143
Commercial plant					
Batch frozen on....	5/2	5/9	5/23	6/6	6/13
Successive weights from	5/10-9/28	5/17-9/28	5/31-10/26	6/14-11/16	6/21-11/16
Maximum age, days	149	142	156	163	156

The following statement indicates the range of weights (in grams) of empty and full cartons.

	University dairy plant			Commercial plant		
	Empty	Full		Empty	Full	
		Extremes	In general		Extremes	In general
Quarts	53	680-550	640-580	46	774-554	650 and +
Pints	37	354-288	340-300	31	360-282	350-300

Obviously weight changes of five grams or less were not significant on packages averaging to weight approximately 625 and 320 grams. Only 21 University-filled packages and one commercial plant-filled package varied more than five grams in weight from their initial weights.

Why did the commercial plant packages retain weight better than those used at the University? The reasons for this tendency are not clear but it may be suggested that the lining used in the commercial plant packages might account for it. In practically every case where gains in weight occurred frost had accumulated on the surface of the packages.

The following table sets forth the weight changes:

Batch	University dairy laboratory			Commercial plant		
	Gains	Losses	No change	Gains	Losses	No change
Vanilla						
I	5	13	8	2	14	12
II	5	15	7	7	5	14
III	4	9	11	4	10	12
IV	0	21	4	2	9	11
V	4	10	12	0	22	2
Totals	18	68	42	15	60	51
Strawberry						
I	2	20	4	9	1	18
II	3	20	4	1	17	8
III	3	14	9	11	3	12
IV	4	11	9	9	4	13
V	7	6	13	4	6	14
Totals	19	71	39	34	31	63
Chocolate						
I	6	7	12	13	2	13
II	6	16	6	4	7	15
III	10	5	11	14	2	10
IV	2	14	10	3	4	19
V	8	5	13	1	21	2
Totals	32	47	52	35	36	59
Maple walnut						
I	1	20	5	7	8	13
II	4	19	5	1	17	8
III	9	6	11	4	4	18
IV	1	17	8	2	4	20
V	2	13	11	0	23	1
Totals	17	75	40	14	56	60
Total by batches						
I	14	60	29	31	25	56
II	18	70	22	13	46	45
III	26	42	42	33	19	52
IV	7	63	31	16	21	63
V	21	34	49	5	72	19
Totals	86	269	173	98	183	235
Changes on percentage basis						
Vanilla	14	53	33	12	48	40
Strawberry	15	55	30	27	24	49
Chocolate	25	36	39	27	28	45
Maple walnut	13	57	30	10	44	46
Averages	16	51	33	19	35	45

Apparently there is little, if any, correlation between weight changes of quart and pint packages of ice cream and their ages. Furthermore the packages containing no one of the four flavors studied were outstandingly susceptible to change. To be sure, as compared with averages, a somewhat larger percentage of the packages containing the strawberry cream gained and a somewhat larger percentage of those containing vanilla cream slightly lost, but in view of the fact that weight changes, when they did occur, were usually very small these differences, and as a rule all weight differences, were of little or no significance.

Volume shrinkage was determined by observation as each package was opened for flavor, body and texture scoring. Those packed at the University laboratory showed a very small line around the edge after being held from 15 to 22 days, which did not change appreciably in size during the storage periods. This defect was more pronounced in some cases than in others but in none would it have been noticed by the average consumer. The packages had to be examined immediately after being taken from the hardening room for the reason that a very few minutes' exposure to room temperature obliterated this line. Objectionable shrinkage occurred in only two of 520 packages (both strawberry), and these only after 114 and 118 days of storage. They were unsalable. No differences in volume shrinkage were manifest among the four flavors and no relation existed between the small line of shrinkage and the size of the package.

The commercial plant packages showed no marked volume shrinkage at any time during the storage period. A very slight looseness developed in from 92 to 120 days, but at no time was it serious. Apparently the inner wrapper or lining of the packages helped to prevent volume shrinkage.

Body and texture held up well in both plants. The principal difficulty with the University packages was the development in from 107 to 114 days of a tough, rubbery film on many vanilla and strawberry surfaces. The maple nut goods were filmed to a lesser extent and the chocolate not at all. One package of strawberry showed marked coarseness at 85 days, another was sandy at 135 days, one vanilla at 135 and one chocolate at 100 days. The other 516 packages, aside from the surface film, remained smooth and salable throughout the entire storage period. Neither flavor nor size of package seemed to affect body and texture except that the surface film did not form on the chocolate goods. It would appear that packaged ice

cream may retain an excellent body and texture for at least 100 days; at any rate 516 of the 520 packages did.

The body and texture of the commercial plant product did not deteriorate or change appreciably during the entire storage period. The chocolate cream in batches I, II and III was weak and lacking in body from the beginning but age did not seem to accentuate this defect. A different formula was used for batches IV and V with excellent results. Because of the way in which fruit and nuts were added to the mix the strawberry and maple nut goods of batch V were coarse from the outset, the former showing this defect most decidedly. Neither fault increased seriously with age. The package lining evidently prevented the formation of the surface film found in the unlined containers.

An analysis of the data on flavor is more difficult because the human equation is brought into the picture more prominently. However, unless otherwise stated, the judgments of flavor quality herein discussed represent the opinions of at least two or more judges.

The University vanilla ice cream began to show the effect of age in from 86 to 100 days, a slight old or stale flavor being evident in two batches in 86 days, in two more at 93 days and in one at 100 days. It is doubtful whether the average consumer would have noted this condition. However, in from 128 to 135 days there was a pronounced and easily recognized old flavor. A slightly stale flavor was found in one batch of strawberry in from 44 to 51 days and in the other four from 72 to 107 days. A definitely disagreeable, old, stale flavor was discernible at 114 to 135 days. In both sorts deterioration seemed to increase with age. The maple nut and chocolate goods stood up well. Whether or not these two flavors are so strong as to mask the slight old fat flavors is a question, but at least nothing objectionable developed in them. The surface film above mentioned had a very strong disagreeable taste. There was no correlation between size of package and flavor changes.

The results in the commercial plant were almost identical to those described above. Chocolate and maple walnut held up through the entire storage period, the only criticism being that the maple flavor faded out a bit after 100 days in some of the batches. However, this was very difficult to ascertain and not at all objectionable. The vanilla began to show signs of age at 92 to 121 days and was definitely objectionable in 142 to 156 days. One of three judges felt that one batch of strawberry showed a slight stale flavor at 29 to 36 days but

the other two were of the opinion that this did not become recognizable until after a lapse of 92 to 99 days. The other four batches were first criticized as showing "off-flavors" after 78 to 99 days. All of the strawberry packages showed pronounced stale (possibly metallic) flavors in 142 to 156 days.

It would appear that chocolate and maple walnut ice creams may be stored in quart or pint packages for periods well in excess of three months in view of the fact that these two flavors were held at hardening room temperatures (-6° F. to -20° F.) for from 128 to 177 days without developing objectionable flavor defects. However, it would seem that vanilla packages should not be held much more than three months, and that it is not safe to hold strawberry cream more than from two to two and one-half months. The greenish discoloration often found in chocolate ice cream stored in unlined cans was not evident at any time during the storage period.

SUMMARY

Vanilla, strawberry, chocolate and maple walnut ice creams stored in quart and pint packages at hardening room temperatures of from -6° F. to -20° F. do not materially change in weight over periods of from 16 to 24 weeks, nor do they shrink appreciably in volume.

Unlined packages of vanilla and strawberry ice creams developed surface film in from 107 to 114 days, maple cream sometimes filmed slightly in about the same time, whereas the chocolate goods developed no film. No films formed when lined packages were used.

Generally speaking the body and texture of packaged ice cream did not deteriorate with age. Chocolate and maple walnut ice creams kept well and retained their desirable flavors over periods of three to four months. Vanilla may develop "off-flavors" in about 100 days and should not be thus stored more than three months. Strawberry is more apt to develop flavor trouble in storage than the other three which were tested and should be held for not more than two months at the utmost. It is safer to hold strawberry ice cream for not more than one month.

Ice cream manufacturers may avoid excessive peak loads in their plants by storing chocolate and maple walnut ice creams, and possibly small amount of vanilla, several weeks ahead of the rush period, thus liberating equipment for use in making ice creams and sherbets that do not keep as well as do these more standard and staple products.

The effect of age on ice cream is well expressed in the words of the first ice cream bulletin published in the United States,¹ "The true age of an ice cream is measured by the age or, rather, the condition of the ingredients of which it is made, not by the length of time since it was last frozen." Ice cream must be good to begin with or successful storage is impossible.

LITERATURE CITED

1. Bayer, A. H. Merchandising of Too Many Flavors Will Result in Loss of Sales. *Ice Cream Trade Journal*, 27, 6, p. 41 (1932).
2. Cole, W. C. Choosing Ice Cream Flavors. *Ice Cream Trade Journal*, 29, 11, p. 31 (1933).
3. Dahle, C. D. and Folker, E. C. Cause of the Off-Flavor in Strawberry Ice Cream. *Ice Cream Review*, 16, 4, p. 31 (1932).
4. Ellenberger, H. B. A Study of Bacteria in Ice Cream During Storage. N. Y. (Cornell) Sta., Memoir 16 (1919).
5. Lucas, P. S. and Merrill, A. C. Vanilla Flavors Do Not Freeze Out of Ice Cream. *Mich. Sta., Quart. Bul.*, 11, 3, p. 118 (1929).
6. Ross, O. E. Why Does a Tallowy Flavor Develop in Strawberry Ice Cream? *Ice Cream Trade Journal*, 29, 7, p. 23 (1923).
7. Schricker, A. C. Package Ice Cream as Bought by the Consumer. *Ice Cream Review*, 18, 7, p. 34 (1935).
8. Scism, S. F. Relation of Age and Temperature to the Physical Qualities of Different Flavored Ice Creams. *Ice Cream Review*, 17, 7 p. 40 (1934).
9. Sommer, H. H. The Theory and Practice of Ice Cream Making, pp. 334-335, 361-362 (1932).
10. Tracy, P. H., Ramsey, R. J., and Ruehe, H. A. A Study of the Causes of a Stale Metallic Flavor in Strawberry Ice Cream. *Ill. Sta., Bul.* 407 (1934).
11. Tracy, P. H. and Ruehe, H. A. Enzyme Activity of Ice Cream Improvers. *Ill. Sta., Bul.* 333 (1929).

¹ Vt. Sta., Bul. 155 (1910).