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A Study of the Manufacture of Frozen Desserts from Dry Ingredients

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A STUDY OF THE MANUFACTURE OF FROZEN DESSERTS FROM DRY INGREDIENTS

by

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INTRODUCTION

In many parts of the world where milk production is limited, there is an opportunity to process dairy foods from imported concentrated milk products. Dry ingredients can be shipped conveniently and some can be stored several months generally without deterioration. In these milk deficient areas, dried ingredients of good quality and with proper processing should increase the use and consumption of dairy products.

A large supply of high quality milk by-products which are fit for human consumption are available in the world today.

Many investigators and manufacturers have used dried milk by-products as a source of milk solids in frozen desserts with favorable results.

It is possible to process ice cream mix using dry ingredients only. Such ingredients include nonfat dry milk, dried buttermilk, dried whey or dried whole milk. Butter, butter oil or vegetable oils may be used as the source of fat.

Dried dairy ingredients can be used to make a good quality ice cream which has a relatively low cost and is convenient to process. In countries where fluid milk is scarce the use of dried products in frozen desserts allows more fresh milk to be marketed as such.

In this study it is planned to investigate the sources, uses in processing, and quality results of dry ingredients in ice cream.

REVIEW OF LITERATURE

Baer, Olson and Burke (5) reported that it is entirely possible to make an ice cream from reconstituted products with satisfactory results if the ingredients used are of good quality. They indicated that skim-milk powder offers probably the most convenient form of milk solids for use in ice cream and requires less storage space than condensed milk.

Norman and Malkames (15) indicated that the use of low heat skim-milk powder as a source of serum solids in ice cream has proved to be very satisfactory by the army in the Philippines. They reported that skim-milk powder has been stored without difficulty for as long as six months under atmospheric conditions. The temperature varied from 75 F to 95 F and relative humidity ranged from 30 to 100 percent. On the other hand, Nielson (14) reported that dry whole milk does not maintain its quality so well as the nonfat dry milk due to deterioration of the fat. Christensen, Decker and Ashworth (7) concluded that powdered whole milk is subject to a variety of off-flavors of which rancid, tallowy or oxidized and stale are influenced by the preheat treatment of the milk previous to concentrating and drying. They further indicated that other factors which may influence the development of these off-flavors are the conditions of storage, such as temperature of storage and inert gas packing.

Nielson (14) pointed that nitrogen packed powdered whole milk is superior to air packed dry whole milk and will store at room temperature for nine months without deterioration while air packed dry whole milk lasts only for four months.

Nielsen (13) indicated that dry whey has been used in ice cream since World War II, but only in the past few years has it gained widespread acceptance. He reported that back in January 1944, Leighton of U.S.D.A. reported whey solids could be used very advantageously in war time ice cream. Rosenberger and Nielson (16) stated that ice cream prepared from whey solids has been judged to be slightly inferior to samples prepared from nonfat dry milk but had no difference in body and texture. Nielsen (13) suggested the most commonly used level of whey in ice cream is 20 percent of the serum solids. Whey at this level gives smoother body and texture with no change in flavor. Nielsen (13) further indicated that the principal factor which has restricted the use of whey in ice cream has been the fear of sandiness. The threat of sandiness has limited the use of other serum solids as well. Rosenberger and Nielson (16) point out that some of the advantages for using spray dried whey powder in ice cream mix are that it: (a) is lower in cost than other common serum solid concentrates, (b) may improve the whipping ability of the mix, (c) is more easily incorporated in mixes than nonfat dry milk solids, and (d) produces drier ice cream at the freezer.

Dried sweet cream buttermilk was reported by Combs (9) to compare very favorably in composition with dried skim-milk. However, dried skim-milk is prepared to contain not more than 1.5 percent of milk fat while sweet cream buttermilk powder will contain more than 5 percent milk fat. That excellent quality of ice cream can be made using sweet cream buttermilk as a source of milk solids not fat was first reported by Combs (8) in 1927. He indicated that ice cream which contained sweet cream buttermilk powder was considered equal or slightly superior to that which contained skim-milk powder as the source of milk solids.

More than 87 million pounds (3) of buttermilk powder were produced in the U.S.A. during 1961, some of which was used in ice cream mixes. But many potential users shy away from dried buttermilk because of uncertain product quality. Amundson (1) concluded that if a high quality, good flavored dry buttermilk is used it can supply all of the serum solids without affecting taste or texture. Researchers (3) at the University of Wisconsin found that the substitution of nonfat dry milk solids with dry buttermilk in ice cream mixes resulted in mixes that whipped faster and made a larger volume of ice cream than conventional mixes. Also, the ice cream was stored for four months without developing off-flavors. Williams, Potter, and Hufnagel (21) concluded that buttermilk solids from sweet cream buttermilk are excellent sources of solid-nonfat for ice cream, are interchangeable with skim-milk solids, and may be blended with skim-milk solids to improve the whipping properties of the mix. They also found that buttermilk solids impart a creaminess to the ice cream not ordinarily obtained with milk solids from usual sources.

Yanasugondha (24) conducted an experiment in 1951 comparing sweet cream buttermilk powder with nonfat dry milk solids in ice cream mixes. Both concentrates were used in the amount of 5 percent of the ice cream mix as additional serum solids other than that supplied by cream and fresh skim-milk. He found that a distinct improvement in the whipping ability of ice cream mixes was obtained through the use of spray process buttermilk powder as the additional source of serum solids in place of skim-milk solids. The normal overrun was obtained in about three minutes less time than with the mixes made with nonfat dry milk solids.

Turnbow, Tracy, and Raffetto (19) indicated that good quality butter of grade 92 score or higher should be used in ice cream. Whitaker

(20) concluded in 1930 that the use of butter in place of cream as the source of fat in ice cream mixes produced a mix of inferior freezing quality. Data recorded by previous workers (6, 11, 18, 22, and 23) indicated that the lecithin content of cream and buttermilk is considerably higher than that of skim-milk and butter. Turnbow et al. (19) pointed out that the advantage of butter is that is is a cheap source of fat and can be shipped and stored several months without deterioration.

Keeney (12) in a survey of 12 states showed that the mellorine-type products are increasing on the market but not at a spectacular rate. Arbuckle (4) observed that mellorine usually sells for 20 cents less per gallon than ice cream. The margin between selling and cost price is quite small however. He also indicated that whipping time and rate of melting may be slower in mellorine-type mix than normal ice cream mix.

METHODS AND PROCEDURES

The dried ingredients[1] used in this experiment included nonfat dry milk solids, dried whole milk, dried buttermilk, dried whey, and commercially prepared powdered ice cream mix. Butter and vegetable oils were used as sources of fat. Granulated sugar, dried stabilizer, dried emulsifier and water were the other constituents.

Five lots of ice cream made from different sources of dried milk solids were compared with regular ice cream made from fresh milk, cream, and plain condensed skim-milk. All mixes were of the same composition. Each lot contained six batches outlined as follows:

Lots 1 to 5:

Batch A using nonfat dry milk solids (NFDM).

Batch B using dry whole milk (DWM).

Batch C using dry buttermilk (DBM).

Batch D using dry whey (DW).

Batch E using commercial powdered mix (COMM).

Batch F using fresh milk, cream, and plain condensed skim-milk as a control (Control).

Butter was used as the source of fat in batches A, B, C, and D.

The composition of the ice cream mix in all batches was 10.5 percent fat, 11.5 percent serum solids, 12.0 percent sugar, 4.0 percent corn syrup solids (24 DE), 0.35 percent stabilizer, and 0.10 percent emulsifier.

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[1] Commercial companies supplying dried ingredients are listed in Appendix Table 25.

Table 1. Composition of ingredients used in experimental batches

Ingredients	Fat	MSNF	H_2O	Salt	Total solids
Nonfat dry milk solids[a]	1.0	95.0	4.0		96.0
Dry whole milk[a]	26.0	69.0	5.0		95.0
Dry buttermilk[a]	5.0	90.0	5.0		95.0
Dry whey[a]		93.0	7.0		93.0
Butter (salted)	80.3	1.0	16.7	2.0	83.3
Vegetable oil	100.0				100.0

[a]Spray process

Table 2. Percentage of ingredients used per batch in pounds

Ingredients	Batch					
	A	B	C	D	E	F
Fresh cream 36%						29.17
Plain condensed skim-milk 30%						23.86
Fresh skim-milk						30.52
Butter	12.97	7.71	12.32	13.13		
Nonfat dry milk solids	12.15					
Dry whole milk		16.67				
Dry buttermilk			12.78			
Dry whey				12.37		
Sugar	12.00	12.00	12.00	12.00		12.00
Corn syrup solids (24 DE)	4.00	4.00	4.00	4.00		4.00
Stabilizer	0.35	0.35	0.35	0.35		0.35
Emulsifier	0.10	0.10	0.10	0.10		0.10
Commercial powdered mix					38.00	
Water	58.43	59.17	58.45	58.05	62.00	
Totals	100.00	100.00	100.00	100.00	100.00	100.00

Stabilizer, commercially known as Hi-Gel containing refined edible marine and vegetable colloids, glycerol mono-di-stearates and dextrose was added to the mix with sugar after reaching 140 F during pasteurization. Emulsifier containing polysorbate 80, glycerol mono-oleate and propylene glycol was added directly with other ingredients prior to heating the mix.

The commercial powdered ice cream mix was packed in cans and was made from cream, milk, sugar, corn syrup solids, vegetable stabilizer, di-sodium phosphate, vanilla, vanillin (an artificial flavor), and U. S. certified color. The mix was carefully used according to manufacturer's direction.

The same composition of ice cream mix, with nonfat dry milk solids as the source of serum solids, was used to compare ice creams containing vegetable oils as different sources of fat. Lots 6 to 11 each contained five batches as follows:

Batch A using oil A (an all-hydrogenated vegetable fat produced entirely from carefully selected vegetable oils).

Batch B using oil B (produced from 100 percent pure hydrogenated domestic vegetable fat).

Batch C using oil C (produced from hydrogenated pure vegetable oil).

Batch D using oil D (produced entirely from unsaturated safflower oil).

Batch E control (using fresh milk, cream, and plain condensed skim-milk).

Each 60-pound batch of ice cream mix was pasteurized for 30 minutes at 160 F then homogenized in a Gaulin two-stage homogenizer at 2500

Table 3. Percentage of ingredients used per batch in pounds for ice cream mix containing vegetable oils

Ingredients	Batch				
	A	B	C	D	E
Fresh cream 36%					29.17
Plain condensed skim-milk 30%					23.86
Fresh skim-milk					30.52
Nonfat dry milk solids	12.15	12.15	12.15	12.15	
Vegetable oil	10.38	10.38	10.38	10.38	
Sugar	12.00	12.00	12.00	12.00	12.00
Corn syrup solids (24 DE)	4.00	4.00	4.00	4.00	4.00
Stabilizer	0.35	0.35	0.35	0.35	0.35
Emulsifier	0.10	0.10	0.10	0.10	0.10
Water	61.02	61.02	61.02	61.02	
Totals	100.00	100.00	100.00	100.00	100.00

pounds on the first and 500 pounds pressure on the second stage. Then it was cooled to 50 F. The mix was aged for 24 hours to 40 F and then frozen in a 40-quart direct expansion ammonia batch freezer.

Titratable acidity was determined for each lot. For each titratable acidity determination a 9-gram sample mix was accurately weighed and titrated undiluted with a standard decinormal sodium hydroxide solution.

At each run, 45 pounds of mix was weighed into the batch freezer which had been adjusted to standard working condition. Three ounces of vanilla extract per 5 gallons of mix was added to all individual mixes for all lots.

At the freezer Draw-Rite reading of 7 which was usually reached in 5 to 6 minutes, the whipper was turned on and the ammonia shut off and every minute thereafter the overrun of the freezing mix was tested on an overrun tester manufactured by Toledo Scale Company, Toledo, Ohio.

Whipping time was recorded from the time the whipper was turned on till the time a 100 percent overrun was reached. The temperature of the mix was determined and recorded each time the overrun was checked.

The overrun tester was calibrated for each mix before freezing. The mixes containing butter and fresh milk product were drawn at 100 percent overrun, while mixes containing vegetable oils failed to reach the desired 100 percent overrun. The thermometer used a fahrenheit type graduated from 0 to 220 degrees.

Samples were drawn from the freezer into two precooled half gallon paper containers and kept in the hardening room at -10 F for later scoring. The remainder of the mix was drawn into two and one-half gallon containers.

Ice cream samples were examined and scored for flavor, body and texture and melt-down properties after four to five days of storage. Scoring of flavor, body, texture, and melt-down was done by two experienced judges of dairy products.

A survey on consumer's preference (Table 24) was made on samples of ice cream containing vegetable oil as the source of fat and control ice cream made from fresh ingredients.

RESULTS AND DISCUSSION

Flavor

In all lots the control ice cream made from fresh ingredients was scored 40, which is the full score for flavor. The ice cream containing nonfat dry milk as a source of serum solids and butter as a source of fat was scored 40 in three lots and 39 in two. The only criticism that the judges noted was a slight cooked flavor. In most instances the judges could distinguish the fresh control ice cream from those made with nonfat dry milk solids.

The ice cream with dry whole milk as a source of milk solids and butter for fat was scored 39 in three instances and 38 in two. It was criticized for having cooked and condensed milk-products flavors. The ice cream made from sweet cream buttermilk powder and butter was scored 39.5 in two lots, 39 in two other lots, and 38 in one. It was criticized for a slight cooked flavor and a condensed milk-products flavor. It was also characterized for richness of flavor. Two sources of buttermilk solids were used because of unsatisfactory results obtained from one source due to defects in the powder. For the same reason, sweet dairy whey powder was obtained from two commercial sources to supply the serum solids in the ice cream with butter as a source of fat. The ice cream made from whey powder solids scored 35 in four lots and 36 in one. It was criticized for acid, stale, bitter, and caramelized flavors.

Table 4. Summary of data on the use of dried milk solids as a source of serum solids and butter as a source of fat

Criteria	NFDM	DWM	DBM	DW	COMM	Control
Titratable acidity (%)	0.220	0.210	0.220	0.268	0.216	0.220
Whipping time (minutes)	8.800	9.200	4.800	6.600	10.800	5.800
Final overrun (%)	100.000	100.000	100.000	100.000	100.000	100.000
Drawing (F) temperature	25.800	25.600	24.000	24.200	25.400	25.000
Condition when drawn	soft	firm	stiff-dry	stiff-dry	firm	firm
Flavor scores and criticism	39.600 ---	38.600 CMP[a]	39.000 sl.cook	35.200 acid	36.200 fishy	40.000 ---
Body and texture scores and criticism	29.400 ---	29.400 ---	29.400 ---	28.400 sl.coarse	28.400 sl.coarse	29.400 ---
Melt-down	sl.whey-off	normal	whey-off	whey-off	normal	normal
Ingredient cost per 100 pounds mix ($)	12.77	12.97	14.52	12.33	20.40	11.94

[a]Condensed milk products

Table 5. Summary of data on use of vegetable oils as a source of fat and nonfat dry milk powder as a source of serum solids

Criteria	Oil A	Oil B	Oil C	Oil D	Control
Titratable acidity (%)	0.222	0.220	0.220	0.220	0.220
Whipping time (minutes)	9.800	10.000	9.600	9.400	5.800
Final overrun (%)	74.400	77.600	80.900	65.200	100.000
Drawing temperature (F)	25.800	25.000	25.000	24.200	25.000
Condition when drawn	v.soft	v.soft	v.soft	v.soft	firm
Flavor scores and criticism	39.000 CMP[a]	39.000 CMP[a]	37.800 oily	35.200 safflower	40.000 ---
Body and texture and criticism	29.400 ---	29.400 ---	29.400 ---	28.400 coarse	29.400 ---
Melt-down	normal	normal	normal	normal	normal
Ingredient cost per 100 pound mix ($)	6.34	6.01	5.90		11.94

[a]Condensed milk products

Table 6. Significant variance table between means of criteria observed in the experiment on the use of different sources of dry milk solids and butter for fat according to Duncan's new multiple range test (17)

Criteria	DW	COMM	DWM	DBM	NFDMS	Control
Flavor	35.2**	36.2**	38.6**	39.0**	39.6**	40.0**

Criteria	DW	COMM	NFDMS	DWM	DBM	Control
Body and texture	28.4	28.4	29.4	29.4	29.4	29.5**

Criteria	DW	DBM	NFDMS	COMM	Control	DWM
Melt-down	3.7**	3.9**	4.2**	4.5	4.5	5.0**

**Significant at the 1 percent level of probability.

Table 7. Significant variance table between means of criteria observed in the experiment on the use of vegetable oils as a source of fat according to Duncan's new multiple range test (17)

Criteria	Oil D	Oil C	Oil A	Oil B	Control
Flavor	35.2**	37.8**	39.0	39.0	40.0**

Criteria	Oil D	Oil A	Oil B	Oil C	Control
Body and texture	28.4**	29.4	29.4	29.4	29.5**

Criteria	Control	Oil C	Oil A	Oil B	Oil D
Melt-down	4.5**	4.8**	5.0	5.0	5.0

**Significant at the 1 percent level of probability.

The ice cream made from a commercial powdered ice cream mix scored 36 in four samples and 37 in the fifth. The flavor criticism was described as stale, fruity, and fishy.

Batches containing vegetable oils as a source of fat and nonfat dried milk solids were also compared with regular fresh ice cream as a control.

Batches containing oil A and oil B were each scored 40 in one lot, 39 in three lots and 38 in one. Both batches were criticized for slight cooked flavor and a condensed milk-products flavor and were not criticized as oily. Ice cream containing oil C, however, was described as oily, slight tallowy, and condensed milk products flavors. It was given a score of 39 in one lot, 38 in two lots, and 37 in two other lots. Oil D batches which used unsaturated safflower oil to supply the fat content in ice cream were easily detected by the judges for objectionable oily flavors. It received a score of 34 in one instance, 35 twice, and 36 in two other instances.

Body and Texture

The average score for body and texture in the control mix was 29.5 in the five lots. A similar average score for the same number of lots was given to the ice cream containing nonfat dry milk, dry whole milk, and dry buttermilk as sources of serum solids and butter as the source of fat. Slight coarseness was noted in some batches of each of the nonfat dry milk, dry whole milk, and dry buttermilk.

Body and texture for the dry whey and commercial powdered ice creams averaged 28.4 and were criticized for coarseness.

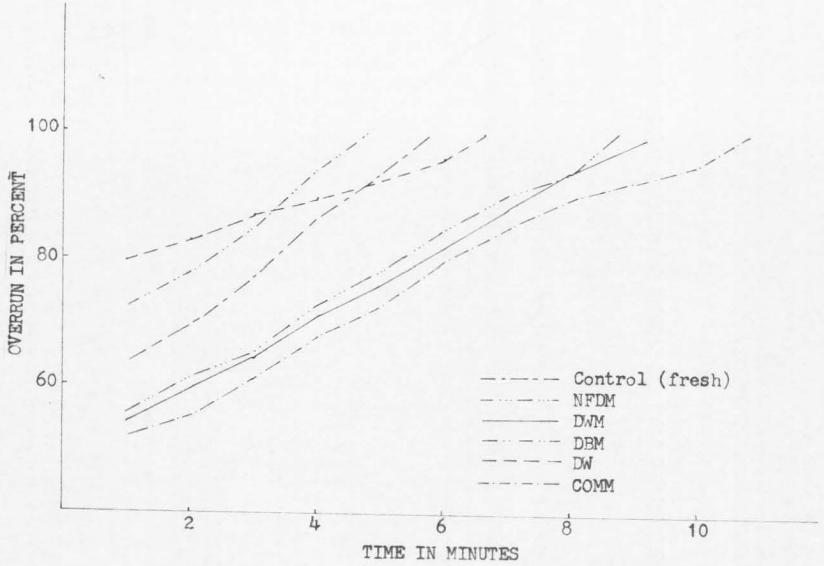

Figure 1. Time-overrun relationships in the comparison of mixes containing different source of dry milk solids.

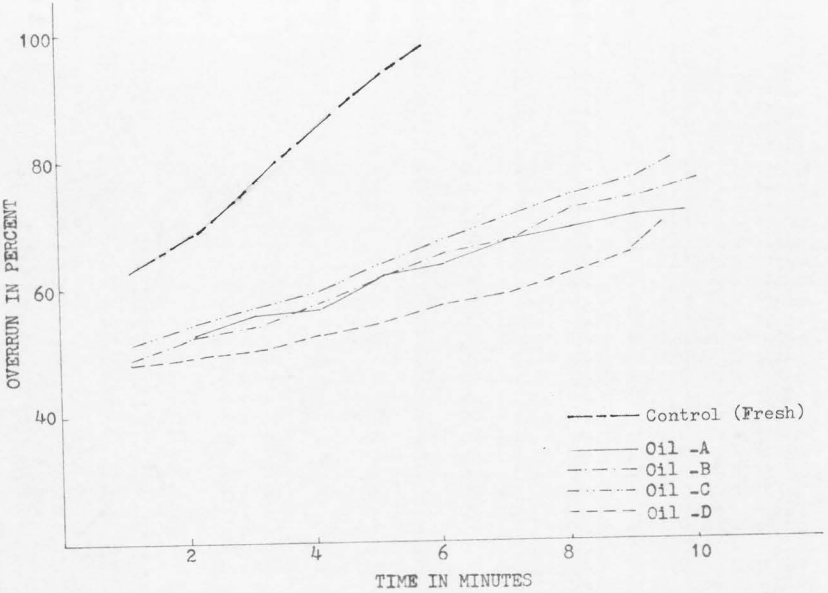

Figure 2. Time-overrun relationship in the comparison of ice cream mixes containing vegetable oils as the source of fat.

In respect to the ice cream made from hydrogenated vegetable oils A, B, and C each had an average score of 29.4 for the five lots while the ice cream containing unsaturated safflower oil received a score of 28.4 for body and texture. The control mix, however, received an average score of 29.5.

Freezing Properties

All ice cream batches containing butter were drawn from the freezer at 100 percent overrun. Table 20 and Figure 1 show that the ice cream mix made from spray process sweet cream dry buttermilk whipped faster than the other mixes included in the experiment. This fully supports previous observations (1, 3, and 18). The average whipping time to reach 100 percent overrun for dry buttermilk mix was 4.8 minutes which is one minute less than the average whipping time needed for the control batch.

Ice cream mixes containing dry whey, nonfat dry milk, dry whole milk, and commercial powdered ice cream mix required more time to whip than the control ice cream mix made from fresh ingredients. Butter as the source of fat is believed to inhibit the whipping ability of the mix (20).

Batches containing vegetable oils as a source of fat required more time to whip than mixes containing butter or fresh cream. None of the mixes containing oil ever reached 100 percent overrun. In most cases it required as much as 10 minutes to reach an overrun of 80 percent or less. The frozen mix showed a tendency of dropping directly as soon as maximum overrun was reached.

The frozen ice cream mix made from dry buttermilk and dry whey with butter as a source of fat, when freshly drawn from the batch freezer at 100 percent overrun was drier and firmer in texture than the other ice cream mixes in the experiment. Such observation coincides with that of Rosenberger and Nielson (16) and Yanasugondha (24).

Ingredient Cost

Table 18 indicates an estimated cost for the ingredients used in this experiment based upon market prices at the time. It is noted from Table 19 and Figure 3 that a slight difference in ingredient cost is shown between the regular fresh ice cream mix and ice cream made from nonfat dry milk solids, dry whole milk, or dry whey. Nevertheless, ice cream mix containing dry buttermilk solids will cost 21.4 percent more than regular fresh mix based on 100 pounds weight. Commercial powdered mix on the other hand exceeded the cost of regular fresh mix by almost 71 percent.

When vegetable oils are used as a source of fat, the resulting ice cream mix will cost approximately 50 percent less than the control mix made from fresh ingredients.

Consumers' Preference

Four groups of consumer jurys averaging sixteen individuals for each group were given samples of ice cream made from vegetable oil A as a source of fat and regular ice cream made from fresh ingredients. Two of the groups who were somewhat acquainted with dairy products showed a preference for the control fresh ice cream over ice cream made from vegetable oil. The same two groups also rated equally ice cream made

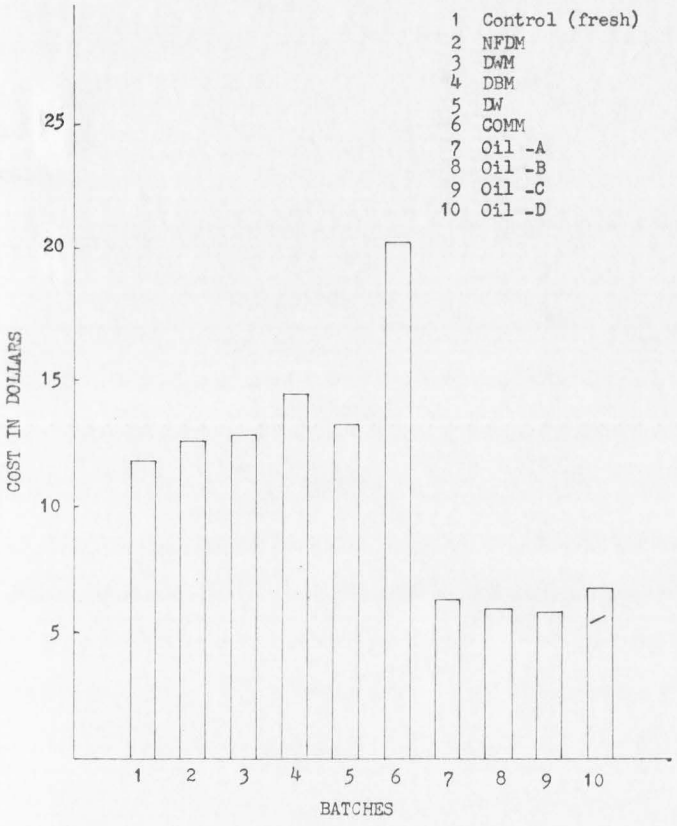

Figure 3. Cost of ingredients for 100-pound batch of ice cream mixes containing different milk solids and vegetable oils.

from nonfat dry milk solids with ice cream made from dry buttermilk, both products were less preferred than either the control fresh ice cream sample or ice cream containing vegetable oil.

The other two groups, however, who were not especially acquainted with dairy products indicated a preference for the vegetable oil product over regular fresh ice cream.

SUMMARY

Investigation on the use of powders as a source of serum solids in the manufacture of ice cream was conducted in this study. Experiments compared ice cream made from different kinds of dried milk solids with regular ice cream made from fresh ingredients.

Dried solids included nonfat dry milk, dried whole milk, dried buttermilk, dried whey, and commercially prepared powdered ice cream mix. Butter and vegetable oils were used as the source of fat.

The ice cream mixes in the experiment all contained 10.5 percent fat, 11.5 percent serum solids, 12.0 percent sugar, 4.0 percent corn syrup solids, 0.35 percent stabilizer, and 0.10 percent emulsifier.

Observations were made on flavor, body and texture, freezing characteristics, and cost of ingredients.

There was a distinctive oily off-flavor in the finished product when polyunsaturated safflower oil was used to furnish the fat in the ice cream. It was a definite oxidized type of flavor detected.

The use of spray process dry sweet buttermilk or dry whey as a source of serum solids in ice cream resulted in a product which was dry in appearance and stiff in consistency when freshly drawn from the freezer.

Ice cream mixes containing dry buttermilk or dry whey whip faster than ice cream containing nonfat dry milk solids or dry whole milk.

When fresh cream or butter are replaced by vegetable oils, the whipping ability of the mixes is reduced.

There was a saving of nearly 50 percent in ingredient cost when vegetable oils (mellorine) were used as sources of fat in the manufacture of ice cream.

Ice cream of comparable quality to that of fresh milk, cream, and plain condensed skim-milk can be made from nonfat dried milk or dry buttermilk when such solids are of good quality.

When high quality dried milk solids are used a good quality of frozen product is usually produced.

It is important to have a reliable source of dried milk solids to insure satisfactory results in the finished product of manufactured ice cream.

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APPENDIX

Table 8. Whipping time in minutes to reach 100 percent with mixes containing different sources of milk solids

Lot	Batch					
	NFDM[a]	DWM[b]	DBM[c]	DW[d]	COMM[e]	Control
1	9	10	5	5	11	6
2	10	9	4	9	9	5
3	10	8	6	7	13	7
4	8	11	4	8	11	5
5	7	8	5	4	10	6
Average	8.8	9.2	4.8	6.6	10.8	5.8

[a]Nonfat dry milk
[b]Dry whole milk
[c]Dry buttermilk
[d]Dry whey
[e]Commercial powdered mix

Table 9. Whipping time in minutes to reach highest[a] percent overrun with mixes containing vegetable oils as a source of fat

Lot	Batch				
	Oil A	Oil B	Oil C	Oil D	Control
1	10	10	11	12	6
2	9	9	9	8	5
3	9	11	7	10	7
4	11	10	10	9	5
5	10	10	11	8	6
Average	9.8	10.0	9.6	9.4	5.8

[a]100 percent overrun was not reached in all mixes containing vegetable oil as a source of fat.

Table 10. Percentage titratable acidity of ice cream mixes after homogenization and cooling to 40 F

Lot	Batch					
	NFDM	DWM	DBM	DW	COMM	Control
1	.220	.220	.220	.270	.220	.220
2	.220	.220	.230	.270	.210	.220
3	.220	.220	.220	.270	.220	.220
4	.220	.220	.230	.260	.220	.220
5	.220	.220	.220	.270	.210	.220
Average	.220	.220	.224	.268	.216	.220

Table 11. Percentage titratable acidity of ice cream mixes after homogenization and cooling to 40 F

Lot	Batch				
	Oil A	Oil B	Oil C	Oil D	Control
1	.230	.220	.220	.220	.220
2	.220	.220	.220	.220	.220
3	.220	.220	.220	.220	.220
4	.220	.220	.220	.220	.220
5	.220	.220	.220	.220	.220
Average	.222	.220	.220	.220	.220

Table 12. Flavor scores and criticisms on ice cream containing different sources of dry milk solids

Lot	Nonfat dry milk		Dry whole milk		Dry buttermilk	
	Score	Criticism	Score	Criticism	Score	Criticism
1	39.0	sl.cooked	38.0	CMP[a]	39.0	sl.cooked
2	39.0	sl.cooked	39.0	sl.cooked	39.0	sl.cooked
3	40.0	----	39.0	sl.cooked	39.5	----
4	40.0	----	39.0	sl.cooked	39.5	----
5	40.0	----	38.0	CMP[a]	38.0	CMP[a]
Average	39.6	----	38.6	----	39.0	----

Lot	Dry whey		Commercial mix		Control	
	Score	Criticism	Score	Criticism	Score	Criticism
1	35.0	acid stale	36.0	stale	40.0	----
2	35.0	caramelized	36.0	fruity	40.0	----
3	36.0	bitter	36.0	fishy	40.0	----
4	35.0	stale	37.0	fishy	40.0	----
5	35.0	acid	36.0	stale	40.0	----
Average	35.2	----	36.2	----	40.0	----

[a]Condensed milk products.

Table 13. Flavor scores and criticisms on ice creams containing vegetable oil as the source of fat

Lot	Oil A		Oil B		Oil C	
	Score	Criticism	Score	Criticism	Score	Criticism
1	39.0	sl.cooked	39.0	sl.cooked	37.0	sl.tallowy
2	39.0	sl.cooked	40.0	----	39.0	sl.cooked
3	40.0	----	39.0	sl.cooked	38.0	CMP[a]
4	39.0	sl.cooked	39.0	CMP[a]	38.0	off-flavor
5	38.0	CMP[a]	38.0	CMP[a]	37.0	oily bitter
Average	39.0	----	39.0	----	37.8	----

Lot	Oil D		Control	
	Score	Criticism	Score	Criticism
1	34.0	oxidized	40.0	----
2	35.0	safflower	40.0	----
3	36.0	safflower	40.0	----
4	36.0	safflower	40.0	----
5	35.0	safflower	40.0	----
Average	35.2	----	40.0	----

[a]Condensed milk products.

Table 14. Body and texture scores and criticisms on ice creams containing different sources of dry milk solids

Lot	Nonfat dry milk		Dry whole milk		Dry buttermilk	
	Score	Criticism	Score	Criticism	Score	Criticism
1	29.0	sl.coarse	29.0	sl.coarse	29.5	----
2	29.5	----	29.5	----	29.5	----
3	29.5	----	29.5	----	29.0	sl.coarse
4	29.5	----	29.5	----	29.5	----
5	29.5	----	29.5	----		----
Average	29.4	----	29.4	----	29.4	----

Lot	Dry whey		Commercial mix		Control	
	Score	Criticism	Score	Criticism	Score	Criticism
1	27.0	coarse	28.0	coarse	29.0	sl.coarse
2	29.0	sl.coarse	29.0	sl.coarse	30.0	----
3	29.0	sl.coarse	29.0	sl.coarse	29.5	----
4	28.0	coarse	29.0	sl.coarse	29.0	----
5	29.0	sl.coarse	27.0	coarse	29.0	----
Average	28.4	----	28.4	----	29.5	----

Table 15. Body and texture scores and criticisms on ice creams containing vegetable oils as a source of fat

Lot	Oil A		Oil B		Oil	
	Score	Criticism	Score	Criticism	Score	Criticism
1	29.0	sl.coarse	29.0	fluffy	29.0	sl.coarse
2	29.5	----	29.5	----	29.5	----
3	29.5	----	29.5	----	29.5	----
4	29.5	----	29.5	----	29.5	----
5	29.5	----	29.5	----	29.5	----
Average	29.4	----	29.4	----	29.4	----

Lot	Oil D		Control	
	Score	Criticism	Score	Criticism
1	29.0	crumby	29.0	sl.coarse
2	28.0	coarse	30.0	----
3	28.5	coarse	29.5	----
4	27.0	coarse	29.5	----
5	29.5	----	29.5	----
Average	28.4	----	29.5	----

Table 16. Melt-down scores on ice cream containing different sources of dry milk solids

Lot	NFDM	DWM	DBM	DW	COMM	Control
1	3.0	5.0	3.0	4.0	3.5	5.0
2	3.0	5.0	4.0	4.0	5.0	4.0
3	5.0	5.0	4.5	3.0	5.0	4.0
4	5.0	5.0	4.0	4.0	4.0	4.5
5	5.0	5.0	4.0	3.5	5.0	5.0
Average	4.2	5.0	3.9	3.7	4.5	4.5

Table 17. Melt-down scores on ice creams containing vegetable oils as a source of fat

Lot	Oil A	Oil B	Oil C	Oil D	Control
1	5.0	5.0	4.0	5.0	5.0
2	5.0	5.0	5.0	5.0	4.0
3	5.0	5.0	5.0	5.0	4.0
4	5.0	5.0	5.0	5.0	4.5
5	5.0	5.0	5.0	5.0	5.0
Average	5.0	5.0	4.8	5.0	4.5

Table 18. Estimated costs for ingredients used in the various ice cream mixes

Ingredients	Dollars per pound
Nonfat dry milk solids	0.16
Dry buttermilk	0.25
Dry whole milk	0.35
Dry sweet whey	0.12
Butter (bulk)	0.69
Serum solids	0.15
Fat	0.80
Granulated sugar	0.10
Corn syrup solids (24 DE)	0.09
Stabilizer (Hi-Gel)	0.49
Emulsifier	0.62
Powdered ice cream mix	0.58
Vegetable oil A	0.22
B	0.21
C	0.20
D	0.27

Table 19. Total ingredients cost per 100 pounds of ice cream mix for all batches

Batch	Dollars
A NFDM	12.78
B DWM	12.97
C DBM	14.52
D DW	12.33
E COMM	20.40
F Fresh	11.94
A Oil A	6.34
B Oil B	6.01
C Oil C	5.90
D Oil D	6.63
E Fresh	11.94

Table 20. Percentage overrun at one minute whipping intervals of all ice cream mixes from time whipper turned on

Batches	Minutes whipping												
	1	2	3	4	5	6	7	8	9	10	11	12	13
						NFDM							
1	57	61	65	73	80	86	92	98	100				
2	58	63	67	71	76	83	85	93	95	100			
3	51	54	59	67	70	76	80	87	94	100			
4	61	64	67	73	81	86	94	100					
5	59	63	70	78	84	95	100						
						DWM							
1	57	60	65	68	72	78	84	86	94	100			
2	59	66	76	79	83	87	91	96	100				
3	50	53	60	67	74	85	95	100					
4	52	56	58	67	70	75	82	88	92	95	100		
5	56	59	68	73	80	88	95	100					
						DBM							
1	70	76	89	97	100								
2	77	82	84	100									
3	68	70	73	87	96	100							
4	74	80	93	100									
5	75	80	85	95	100								
						DW							
1	80	85	92	96	100								
2	75	78	82	84	86	89	91	95	100				
3	72	79	83	87	91	96	100						
4	77	80	83	85	89	95	98	100					
5	90	93	95	100									
						COMM							
1	53	57	58	68	74	83	88	90	93	95	100		
2	51	57	66	73	80	87	92	98	100				
3	54	58	62	65	68	74	77	82	86	89	91	95	100
4	50	55	59	66	69	74	81	83	89	96	100		
5	53	58	62	68	76	82	89	91	97	100			

Table 20. Continued.

Batches	Minutes whipping												
	1	2	3	4	5	6	7	8	9	10	11	12	13
						Control							
1	66	72	74	88	93	100							
2	65	73	82	89	100								
3	61	66	72	79	89	96	100						
4	67	76	88	94	100								
5	63	69	77	84	93	100							
						Oil A							
1	46	47	51	52	55	60	63	65	66	70			
2	54	59	63	65	70	72	76	77	79				
3	52	54	58	59	65	69	71	75	77				
4	45	51	54	55	58	61	63	64	68	71	74		
5	48	50	53	57	60	63	66	68	70	72			
						Oil B							
1	48	49	50	53	58	62	64	68	73	74			
2	49	52	56	61	63	65	66	70	73				
3	47	52	55	58	63	67	71	76	79	83	87		
4	50	53	54	57	61	65	69	72	72	73			
5	52	55	56	62	66	70	72	77	79	81			
						Oil C							
1	48	49	50	55	57	61	66	73	75	77	78		
2	52	55	57	59	63	65	70	73	75				
3	55	60	62	67	73	76	80						
4	51	53	55	59	64	68	74	82	86	90	92		
5	50	53	56	58	61	67	71	74	76	79			
						Oil D							
1	48	49	50	55	57	61	66	73	75	77	78	79	
2	47	49	50	51	53	55	59	61					
3	49	51	52	54	57	58	59	62	63	65			
4	46	47	49	50	54	56	57	59	60				
5	50	50	52	54	55	58	60	61					

Table 21. Drawing temperature of frozen ice cream mixes drawn at 100 percent overrun

Lot	NFDM	DWM	DBM	DW	COMM	Control
1	26	26	24	24	26	24
2	26	25	23	24	24	25
3	26	25	25	25	26	26
4	26	26	24	25	26	25
5	25	26	24	23	25	25
Average	25.8	25.6	24.0	24.2	25.4	25.0

Table 22. Drawing temperature of frozen ice cream mixes containing vegetable oils

Lot	Oil A	Oil B	Oil C	Oil D	Control
1	26	26	26	25	24
2	26	24	25	24	25
3	26	25	24	25	26
4	26	25	25	24	25
5	25	25	25	23	25
Average	25.8	25.0	25.0	24.2	25.0

Table 23. Approximate composition of dry ingredients used in ice cream mixes (10)

Ingredients	Fat	Milk solid not fat	Total solids
Nonfat dry milk solids	0.0	97.0	97.0
Whole milk powder	26.0	72.0	98.0
Dry buttermilk	5.0	91.0	96.0
Dry whey solids	0.0	93.0	93.0
Butter (unsalted)	84.0	1.0	85.0

Table 24. Consumers' preference on tested ice cream samples containing vegetable oil and fresh control ingredients

Group	Type	Number	Voted preference for	
			Control fresh	Vegetable oil
A	Business Administration students	14	5	9
B	International students	19	8	11
C	Dairy students	18	12	6
D	Dairy industrialists	14	12	2
Averages		16	9	7

Table 25. Commercial companies supplying dried ingredients for all batches

Ingredient	Company	Address
Nonfat dry milk	Galloway-West	Shawano, Wisconsin
Dry whole milk	Land O'Lakes Creameries, Inc.	Minneapolis 13, Minnesota
Dry buttermilk	1. Galloway-West 2. Badger Consolidated Dairy Corp.	Shawano, Wisconsin Shawano, Wisconsin
Dry whey	1. Foremost Dairies 2. Cache Valley Dairy Assn.	Burlingham, California Amalga, Utah
Powdered ice cream mix	Golden State Co., Ltd.	San Francisco, California
Stabilizer (Hi-Gel)	Germantown Mfg. Co.	Philadelphia 31, Pennsylvania
Emulsifier	DREW Chemical Corp.	New York 36, New York
Butter	Utah State University Creamery	Logan, Utah
Vegetable oil A (silver frost)	Proctor and Gamble Distributing Co.	Los Angeles, California
Vegetable oil B (velvet)	Anderson Clayton and Co.	Dallas 21, Texas
Vegetable oil C (frosto V)	Wilson and Co.	Omaha 7, Nebraska
Vegetable oil D	Vegetable Oil Products Co., Inc.	Wilmington, California
Corn syrup solids	American Maize Products Co.	Chicago, Illinois