5-1951

A Comparison of Sweet Cream Buttermilk Powder with Nonfat Dried Milk Solids in the Manufacture of Ice Cream

Davi Yanasugondha

Utah State University

A COMPARISON OF SWEET CREAM BUTTERMILK POWDER WITH NONFAT DRIED MILK SOLIDS IN THE MANUFACTURE OF ICE CREAM

by

Davi Yanasugondha

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

SCHOOL OF AGRICULTURE

1951

Utah State Agricultural College.

Logan, Utah

The author wishes to express his sincere appreciation to Professor Arthur J. Morris and Professor Paul B. Larsen for their guidance throughout this entire experiment.

TABLE OF CONTENTS

INTRODUCTION

Properly dried sweet cream buttermilk, because of its high fat and lecithin contents, should make superior ice cream. Its use as a source of serum solids in ice cream mix would open an outlet for this butter by-product and would serve the needs of ice cream manufacturers during nonfat dry milk solids shortage and it may make a higher score ice cream.

The demand for milk solids has been increasing so rapidly that today the by-products of the dairy industry are being utilized as sources of human food to a much greater extent than before. In past years the greater bulk of creamery buttermilk has been utilized as animal feeds. Attempts are being made to convert more of this by-product into channels of human consumption. As the manufacture of sweet cream butter is increasing at a rapid pace, a larger supply of buttermilk product of high quality which is fit for human consumption is available in the market.

Many previous investigators have used buttermilk products as a source of serum solids in ice cream mix with favorable results. The advantage claimed has been that it tends to improve the whipping ability of ice cream mixes and to impart richer flavor to the product. These beneficial qualities have been attributed to the butterfat and the phospholipids, of which lecithin is predominant. The work of Chapman (10) and Supplee (35) shows that buttermilk and cream contains several times as much licithin as skimmilk (table 1). The amounts of total phospholipids reported by Holm *et al* (18) and Wright *et al* (44) (45) are approximately 1.77 per cent in dry buttermilk and 1.06 per cent in dry skimmilk.

Table 1. Lecithin in Milk Products

Material	Average Percentage of Lecithin
Milk	.0447
Cream	.1981
Skimmilk	.0165
Buttermilk	.1302
Butter (raw sweet cream)	.0723
Butter (pasteurized ripened)	.0433

REVIEW OF LITERATURE

In 1927, Combs (11) reported the use of powdered sweet cream buttermilk in ice cream. The ice cream which contained sweet cream buttermilk powder was considered equal, or slightly superior to that which contained skimmilk powder as the source of milk solids.

Combs (12) recommended the use of drum process dry milk in ice cream when a great portion of spray dried skimmilk had to be set aside for delivery to the Federal Surplus Commodities Corporation in 1942. Combs (12) pointed out the great possibility of the use of dry sweet cream buttermilk solids in ice cream mix and emphasized the use of the drum processed powder which he claimed was more easily obtainable at the time and somewhat easier to handle as the drum process dry product is less hygroscopic than that of the spray process.

Thurston and Barnhart (39) concluded that the phospholipids of milk are substances that contribute to the richness of flavor in milk products. Buttermilk from sweet cream has a richer flavor probably because of the presence of a relatively high percentage of phospholipids left in the buttermilk as the result of their disengagement from the fat globules during churning.

Whitaker (42) reported in 1930 the inferior freezing qualities of ice cream mix in which butter was used in place of cream as the source of butterfat. The freezing qualities improved when the buttermilk collected when the butter was made was added back to the mix. The time to reach 90 per cent overrun was 12 minutes in the butter-skimmilk mix against 8 minutes in the butter-buttermilk mix, a saving of 4 minutes whipping time. Since results by previous workers (10) (18) (35) (44) (45) indicated that the lecithin content of cream and buttermilk is considerably higher than that of skimmilk and butter, Whitaker also suggested that the lecithin incorporated in ice cream with cream, buttermilk or egg yolk may be responsible for the difference in the freezing properties observed when this material is partially lacking in the mix.

Davis (13) substituted sweet cream buttermilk powder for gelatin in ice cream mix. The result of the experiment indicated that sweet cream buttermilk powder does not possess any gel value in ice cream mix.

Walts and Dahle (41) added dried egg yolks, egg lecithin, and soybean lecithin to ice cream mixes made from butter and dried skimmilk. Addition of .5 per cent dried egg yolks resulted in the saving of 2.6 minutes to obtain 100 per cent overrun and the effect was more pronounced in butter mixes than in cream mixes. Egg lecithin also improved the whipping ability of ice cream but soybean lecithin was detrimental to whipping ability. They also found whip improvement with the use of sweet cream buttermilk in ice cream mix. They believed that the beneficial results of egg yolk on the whipping properties of ice cream mixes are due to a lecithin-protein complex in egg yolk and that a similar lecithin-protein complex in buttermilk is responsible for its beneficial effect.

Tracy (37) recommended meeting manufacturing problems with the use of buttermilk concentrates to supplement milk solids-not-fat in ice cream mixes. He found improvements in whipping qualities of the ice cream mixes and in the body of the ice cream with the use of sour cream buttermilk concentrate containing 31.86 per cent solids and 1.05 per cent titratable acidity. However, the maximum amount of the condensed buttermilk solids that could be used, under the conditions of his experiment, without any noticeable effect upon flavor of the ice cream was approximately 1.67 per cent.

Roller process sweet cream buttermilk powder was used by Thomas and Combs (36) as additional source of milk solids-not-fat in the ice cream mix as compared to the control mix in which the roller process sweet skimmilk powder from the same milk was used. No marked difference in viscosities of the ice cream mixes was found. However, the use of roller process sweet cream buttermilk powder was concluded to result in greater rate of whipping than when using roller process skimmilk powder and one to two minutes could be saved to obtain a normal overrun. This was true when either cream or sweet butter was used as the source of butterfat for the mix. In many instances it was found that the roller process sweet cream buttermilk powder tends to impart richer flavor and less cooked flavor to the ice cream than roller process skimmilk powder. There was no significant difference between buttermilk concentrates from creams of different percentages of butterfat.

Williams, Potter and Hufnagel (43) used sweetened and plain condensed sweet cream buttermilks and plain condensed neutralized buttermilk from sour cream as sources of serum solids in ice cream mix. The concentrated sweet cream buttermilk either plain or sweetened did improve the whipping ability, the maximum overrun reaching 140 per cent in 10 minutes and remaining there 15 minutes. They concluded that buttermilk solids from sweet cream buttermilk are excellent sources of solids-not-fat for ice cream, are interchangeable with skimmilk solids and may be blended with skimmilk solids to improve the whipping properties of the mix, and that buttermilk solids impart a creaminess to the ice cream not ordinarily obtained with milk solids from more usual sources. The buttermilk from sour cream was objectionable and was indicated by inferior whipping properties and distinct off flavor even when only one half of the additional serum solids was substituted with sour cream buttermilk solids.

MATERIALS AND PROCEDURE

The buttermilk solids used in the experiment were in the form of commercial spray-dried sweet cream buttermilk powder obtained from Medford Co-Op. Creamery Company, Medford, Wisconsin. The nonfat dry milk solids were also in the form of spray-dried commercial powder, and a fresh supply of this powder was always available throughout the experiment. As soon as the buttermilk solids powder arrived it was kept in a cold room at a temperature of 40-50° F. in order to minimize any possible deterioration.

The composition of the ice cream mix in the experiment was 13 per cent fat, 11 per cent serum solids, 14 per cent sugar, and .3 per cent gelatin.

The butterfat of all batches of experimental ice cream mixes was supplied by sweet cream separated at the college creamery from A grade milk and standardized to 33 per cent butterfat.

Fresh skimmilk was used to make up the bulk of the ice cream mix. The amount of serum solids lacking was supplied by the serum solid concentrates, namely: by nonfat dry milk solids in the first or control lot, by nonfat dry milk solids and sweet cream buttermilk powder in the second lot, and by sweet cream buttermilk powder in the third lot.

The experimental samples of the nonfat dry milk solids and sweet cream buttermilk powder were analysed for fat and moisture. The method described by Mojonnier and Troy (25) was followed for the butterfat determinations and the toluene method as described by the Milk Industry Foundation (1) was employed for the moisture determinations. From the analyses, 1.6 and 5.2 per cent fat and 3.2 and 4.5 per cent moisture were obtained from the nonfat dry milk solids and sweet cream buttermilk powder respectively. For the sake of simplicity 1.5 and 5 per cent fat and 3.0 and 4.5 per cent moisture were used in figuring the ice cream mixes. The formulas of the mixes on 100 pounds basis were:

	Lot 1	Lot 2	Lot 3
33% cream	39.16	38.86	38.57
Skimmilk	41.40	41.55	41.69
Nonfat dry milk solids	5.14	2.57	---
Sweet cream buttermilk solids	---	2.72	5.44
Sugar	14.00	14.00	14.00
Gelatin	.30	.30	.30
TOTAL	100.00	100.00	100.00

Each ice cream mix was prepared in 85 pound batches in a 10-gallon can, pasteurized 30 minutes at 160° F., then homogenized in a Gaulin two stage homogenizer at 2,700 and 500 pounds pressure, and then cooled rapidly to 50° F. in a cold water bath. The mix was aged in the cold bath for 18-24 hours and then frozen in a 40-quart direct expansion ammonia batch ice cream freezer. As soon as the mix was cooled down to 50° F. samples were collected in half-pint sampling bottles for titratable acidity, pH, original viscosity, butterfat, and total solids content tests. All these tests were done as soon as possible after samples were collected, with the exception of butterfat and total solids determinations.

In each titratable acidity determination a 9-gram sample mix was accurately weighed and titrated undiluted with standard decinormal sodium hydroxide solution. pH reading was made with a Beckman pH meter, 0.2 molar potassium acid phthalate solution diluted with distilled water 1:3 being used as a buffer solution with designated pH 3.98. Viscosities were read and reported in degrees retardation at 54° F. with Mojonnier-Doolittle ball viscosimeter. Butterfat and total solids tests were done according to methods described by Mojonnier and Troy (25).

After aging, before the mix was taken for freezing, the apparent and basic viscosity readings were made with the same viscosimeter described in the previous paragraph. The basic viscosity was determined after the mix was stirred vigorously with a hand stirrer for three minutes.

At each run, 40 pounds of mix was weighed and admitted into the freezer, which had been adjusted to standard working conditions. The necessary amounts of color and vanilla extract were added. At the Draw-Rite reading of 7, which was usually reached in four minutes and thirty seconds, 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. Concurrently with the testing of overrun the temperature of the mix was determined and the Draw-Rite reading was recorded.

The overrun tester was calibrated for each mix before freezing. The tester was graduated up to 140 per cent for the mixes under experiment and any swell beyond this limit was read by proximation. The thermometer used was a centigrade type graduated from 30 to -30 degrees with one-degree graduations. The one-degree space was five millimeters wide and thus reading to a tenth of a degree centigrade was possible with reasonable ease and accuracy. The bulb of this thermometer was kept at a temperature close to that of the freezing ice cream to be tested at the moment by being dipped in a small portion of frozen ice cream mix. All these centigrade readings were later converted into degrees Fahrenheit.

At 90 per cent overrun samples were drawn into four pre-cooled half-pint paper containers and kept in the hardening room at -10° F. for later scoring. The remainder of the mix was allowed to whip further until the maximum overrun was attained, which was indicated by no further increase in overrun for several minutes or by decrease in overrun.

When the overrun was not obtained exactly at the minute the overrun recording was made, the whipping time to reach 90 per cent overrun was calculated from the pair of two successive readings between which the overrun was reached, with the assumption that overrun was increased proportionately with time during any one minute interval. Similar procedure was followed to obtain the drawing temperature of a frozen mix at 90 per cent overrun, assuming that temperature was raised proportionately with time during any one minute interval.

Ice cream samples were examined for flavor, body, and texture and melt-down properties after one week and four weeks of storage. Scoring of flavor and body and texture was done by two experienced judges of dairy products. In the observation of the melt-down characteristics the ice creams were dipped with an ice cream disher and placed in flat bottomed round porcelain dishes of six inches bottom diameter and allowed to melt in 75° F. room temperature.

RESULTS AND DISCUSSION

Mix Composition

The butterfat content of all the mixes averaged 12.84 to 13.01 per cent, ranging between 12.38 per cent and 13.63 per cent. The total solids content averaged 38.02 - 38.30 per cent, ranging between 37.33 per cent and 38.87 per cent.

In all the formulas of mixes the amount of serum solids needed to be supplemented by serum solids concentrates was 4.91 pounds, or 4.91 per cent, which was supplied by the concentrates of the kind and quality designed in the experiment.

Titratable Acidity and pH

The average titratable acidities for the whole period were .2181 per cent for the control mixes and .2162 and .2116 per cent for the other two mixes containing one-half and one full amount of sweet cream buttermilk solids respectively. During the experiment the buttermilk mixes required just slightly but consistently less standard alkaline titer than the control mixes. This fact shows significance statistically as shown in tables 3 and 4. The mix containing half amount of buttermilk solids did not differ appreciably from the control. However, the pH readings of the three batches of ice cream (tables 3, 4, 7) show no differences whatsoever.

Viscosities

The buttermilk powder was not found to possess any special gel ability under the experimented conditions as indicated by the mix viscosities after aging. No difference could be found in original, apparent, or basic viscosities among the three kinds of mixes.

Table 2. Summary of data on observations on the use of nonfat dry milk solids and sweet cream buttermilk powder as additional serum solids in ice cream mixes.

Criteria	NFDMS[1]	NFDMS[3] + SCBMS	SCBMS[2]	NFDMS + .2%[4] Emulsifier
Titratable acidity (%)	.2181	.2162	.2116	
pH	6.32	6.32	6.31	
Original viscosity (° retardation)	37	36	40	
Apparent viscosity (° retardation)	354	343	340	
Basic viscosity (° retardation)	63	65	68	
Whipping time (min.)	5.67	3.18	2.54	2.31
Final overrun (%)	90	90	90	90
Temperature when drawn (°F)	25.52	24.79	24.52	24.70
Conditions when drawn	soft-wet	firm-dry	firm-dry	firm-dry
Flavor scores and criticisms				
1st week	40.00	39.69	39.44	39.75
	---	---	---	---
4th week	40.00	39.69	39.56	39.75
	---	---	---	---
Body and texture scores and criticisms				
1st week	29.62	29.81	29.93	29.75
	---	---	---	---
4th week	29.19	29.37	29.56	29.75
	---	---	---	---
Melting properties	normal	normal	normal	normal
Appearance of melt-down	normal	normal	normal	sl. whey-off

1 Nonfat dry milk solids.

2 Sweet cream buttermilk solids.

3 50% NFDMS plus 50% SCBMS.

4 Observations on the use of .2% emulsifier were made from two trials.

Table 3. Variance table of criteria observed in the experiment on the use of sweet cream buttermilk powder in ice cream.

Treatment	% Titratable Acidity	Minutes Whipping Time	Minutes to Max. Overrun	°F Draw. Tempt.	% Maximum Overrun
NFDMS	.2181	5.67	9.12	25.52	104
NFDMS + SCBMS	.2162	3.18	8.50	24.79	145
SCBMS	.2116	2.54	7.75	24.52	149
$LSD_{.05}$	.0023	.73	1.13	.24	8
$LSD_{.01}$	.0032	1.01	1.57	.33	11

$LSD_{.05}$ Least significant difference at 5 per cent level.

$LSD_{.01}$ Least significant difference at 1 per cent level.

Table 4. Mean squares of criteria observed in the experiment on the use of sweet cream buttermilk powder in ice cream.

	Titratable Acidity	pH	Original Viscosity	Apparent Viscosity	Basic Viscosity	Minutes Whipping Time	Minutes to Max. Overrun	°F Draw Tempt.	% Max. Overrun
Treatment	.0000914**	.0004	43.79	357	61	22.26**	3.79*	2.15**	4,950**
Trial	.0001690	.0049	39.14	6,617	183	.46	2.09	.20	65
Error	.0000045	.0007	17.84	3,597	29	.46	1.12	.05	56

* Significant.

** Highly significant.

Freezing Properties

Table 13 and figure 1 show that the ice cream mix containing sweet cream buttermilk powder whipped faster and to a higher percentage of overrun than the control mixes. The mixes containing full amount of buttermilk powder had the shortest time of whipping to normal overrun of 90 per cent. The average saving of time was 3-13 minutes, and in most instances the whipping time was between two to three minutes. In these full amount buttermilk mixes there was one instance in which the whipping time was below two minutes. The mixes containing one-half amount of buttermilk powder ranked second in whipping rate which was close to that of the full amount buttermilk mixes. The control mixes containing no buttermilk powder whipped the worst and in two instances it took as long as seven minutes to whip the control mixes to 90 per cent overrun. The saving of whipping time by the use of buttermilk powder was of statistical significance.

In five instances out of eight the full amount buttermilk powder mixes whipped up to 150 per cent easily, in two such instances out of eight in the mixes containing half amount of buttermilk powder. The mixes containing buttermilk powder had a tendency to remain at the maximum for several minutes though the whipping was not continued until the overrun actually dropped while the time-overrun curve of the control mixes went down soon after the peak was reached. This phenomenon partially supports that stated by Williams and others (43).

The temperature-overrun relationships in figure 2 show that the capacity to overrun at given temperature was greater for the mixes which contained buttermilk powder than the control throughout that part of whipping process where straight lines relationship existed. As the straight lines relationship was obtained right from the first minute after whipping commenced, it should reveal that the whipping temperature during the freezing process of this experiment was not far from the ideal one as far as the minimum time to reach the desired normal overrun for a particular mix is concerned.

The Draw-Rite readings (fig.3) served as evidence to show that the ice creams which contained sweet cream buttermilk powder were greater in consistency than the control throughout the major portion of the whipping period.

The frozen ice cream mix freshly drawn at 90 per cent overrun was firmer and drier in the formula containing buttermilk powder than in that of the control and was lower in temperature by 0.73-1.00 ^{o}F. Even at higher overrun when the frozen mix had become soft the buttermilk mixes still exhibited drier appearance. In general, the addition of such amounts of buttermilk powder contributed very favorable freezing work situations consisting of rapid rate of whipping and greater consistency of the mix when drawn at normal overrun.

Flavor, Body and Texture, Melt-down Properties

During the first week storage after freezing and hardening, the control ice cream was scored 40, which is the full score, in all instances. The ice cream containing one-half amount buttermilk powder was scored 40 in three and 39.5 in five instances. The full amount buttermilk powder ice cream was scored 40 in one instance, 39.5 in five, and 39 in two instances. The only criticism that the judges

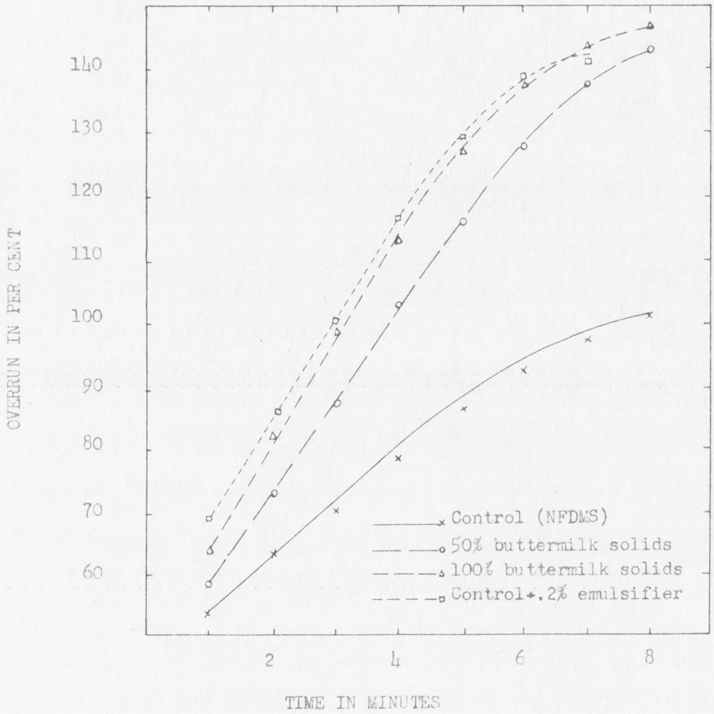

Fig. 1 Time-overrun relationships in the comparison of sweet cream buttermilk powder and nonfat dry milk solids as additional serum solids in ice cream mixes.

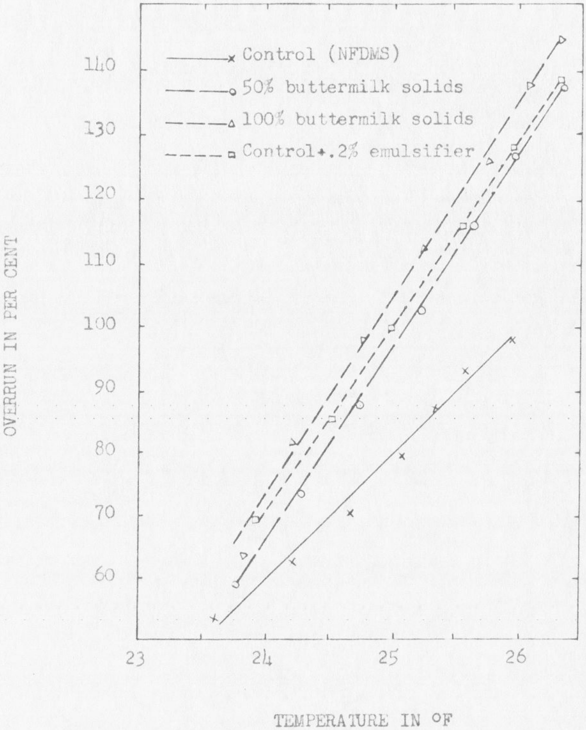

Fig. 2 Temperature-overrun relationships in the comparison of sweet cream buttermilk powder and nonfat dry milk solids as additional serum solids in ice cream mixes.

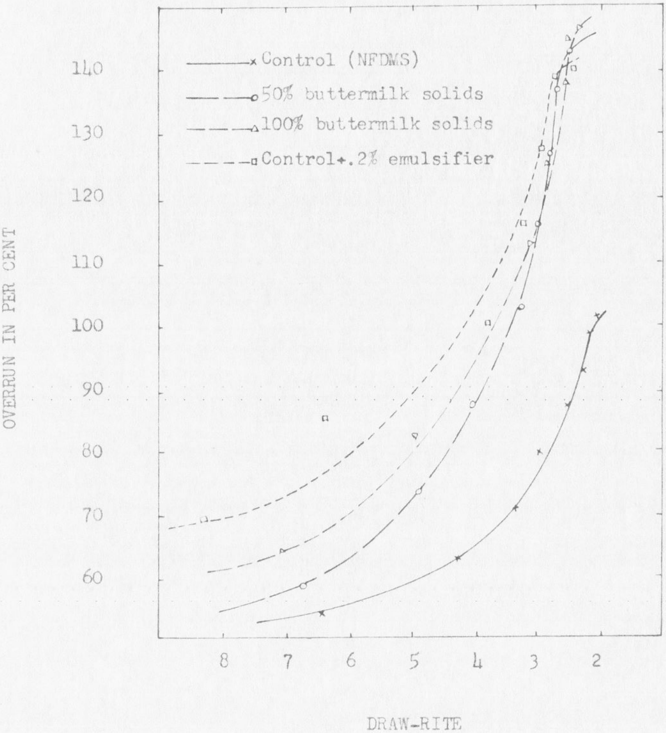

Fig. 3 DrawRite-overrun relationships in the comparison of sweet cream buttermilk powder and nonfat dry milk solids as additional serum solids in ice cream mixes.

could apply was "lack of freshness". In most instances the judges could identify the buttermilk ice creams from the control ones.

In body and texture the buttermilk ice cream scored slightly higher at this period. No criticism was applied as the defect was not such that would justify criticism. Out of eight, the number of instances in which the ice cream samples scored full score were, 2 in the control, 5 in the one-half amount buttermilk, and 7 in the full amount buttermilk ice creams. The rest of the samples scored 29.5. There was no instance where the judges scored the control better than the buttermilk ice cream.

After four weeks storage all samples still retained their excellent qualities. No appreciable change could be observed in flavor. However, the body and texture showed slight decline as scores dropped slightly and the number of criticisms had the tendency to increase, slightly more so in the control ice cream than in the buttermilk ice cream. The only criticism applied was "slightly coarse" and one point was the highest cut on the score of any sample where criticism was justified. Out of eight the number of instances where criticism was applied was 5 in the control samples, 2 in the half-amount buttermilk samples, and 1 in the full amount buttermilk samples.

In all instances, in all samples of ice creams, and during all periods, no defect could be observed in the melting characteristics and in the melt-down properties. The samples were described as "normal".

Buttermilk vs. Whipping Agent

Towards the end of the experiment when the whip improving property of sweet cream buttermilk powder was realized, a few trials of ice cream were made with the formula of the control mix with the addition of .2 per cent of a brand of commercial ice cream mix emulsifier which contained polyoxyethylene sorbitan monostearate and sodium carboxy methyl cellulose as essential ingredients. The aim was to compare buttermilk with the commercial whip improver. Data were collected with special emphasis on freezing properties and body and texture of the final product.

The mixes which contained .2 per cent of commercial ice cream mix emulsifier whipped at a slightly greater rate than the full amount buttermilk powder mixes but did not reach as high a maximum overrun, illustrated in fig. 1. It gave the same favorable conditions of the mix freshly frozen drawn at normal overrun and the same excellent body and texture of the product. It is not probable that buttermilk powder is a better whip improver than a commercial whipping agent.

Slight wheying-off was observed in the melt-down of the ice cream containing this whipping agent.

SUMMARY AND CONCLUSIONS

Experiments were conducted on a comparison of sweet cream buttermilk powder with nonfat dry milk solids in ice cream making. The skimmilk powder was used in the control mixes. Both concentrates were commercial spray process powders and were used as additional serum solids other than that supplied by cream and fresh skimmilk. Fresh 33 per cent cream was used as source of butterfat in all mixes. These additional concentrates amounted to 4.91 per cent serum solids, or roughly 5 per cent, of the ice cream mix. The ice cream mixes under the experiment contained 14 per cent sugar, .3 per cent gelatin, and averaged 12.84 - 13.01 per cent fat and 38.02 - 38.22 per cent total solids. Observations were made on titratable acidity and pH of the mixes, freezing characteristics, flavor, and body and texture of the product.

The following conclusions are drawn.

1. There were no consistent or marked differences in the viscosities of the ice cream mixes either original, apparent, or basic.

2. 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 skimmilk solids. The normal overrun was obtained in about three minutes less time than the mixes made with nonfat dry milk solids as additional serum solids.

3. The mixes containing sweet cream buttermilk powder whipped to a maximum overrun of 136-150 per cent and had tendency to remain there for several minutes. The skimmilk powder mixes whipped to a

maximum overrun of 90-120 per cent.

4. The use of spray process buttermilk powder in ice cream results in a product which is drier in appearance and stiffer in consistency when freshly drawn from the freezer.

5. Spray process dry buttermilk powder makes a satisfactory product. It does not impart any marked improvement in flavor over the spray process nonfat dry milk solids but does improve body and texture of the product.

6. Ice cream containing as high as 5.44 per cent spray process buttermilk powder can remain quite fresh after four weeks storage.

7. Spray process buttermilk powder used in ice cream mix to an extent equivalent to 5 per cent buttermilk solids compares favorably, if not as good nor any better, in whip improving ability, with commercial polyoxyethylene sorbitan monostearate - sodium carboxy methyl cellulose whip improver used at the level of .2 per cent.

APPENDIX

Table 5. Percentage titratable acidity of ice cream mixes after homogenization and cooling to 50° F.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
C	.2250	.2200	.2175
D	.2175	.2150	.2150
E	.2300	.2275	.2200
F	.2250	.2275	.2200
G	.2125	.2075	.2000
H	.2100	.2100	.2050
I	.2100	.2100	.2075
J	.2150	.2125	.2075
AVERAGE	.2181	.2162	.2116

Table 6. pH value of ice cream mixes after homogenization and cooling to 50° F.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
C	6.37	6.37	6.36
D	6.39	6.36	6.26
E	6.27	6.31	6.29
F	6.27	6.26	6.28
G	6.30	6.30	6.32
H	6.39	6.37	6.38
I	6.30	6.28	6.29
J	6.29	6.29	6.29
AVERAGE	6.32	6.32	6.31

Table 7. Viscosities of different ice cream mixes tested at 54° F with Mojonnier-Doolittle viscosimeter read in degrees retardation.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
	1. Original viscosity		
C	30	32	32
D	42	40	40
E	40	40	44
F	40	41	46
G	38	36	36
H	42	38	35
I	31	32	46
J	32	30	45
AVERAGE	37	36	40
	2. Apparent viscosity		
C	358	319	378
D	403	405	325
E	318	280	348
F	323	283	380
G	460	470	293
H	440	446	315
I	250	240	332
J	283	300	350
AVERAGE	354	343	340
	3. Basic viscosity		
C	60	64	63
D	66	68	61
E	56	56	65
F	58	56	66
G	75	74	74
H	78	86	75
I	58	61	71
J	50	53	70
AVERAGE	63	65	68

Table 8. Whipping time in minutes to reach 90 per cent overrun of ice cream mixes containing nonfat dry milk solids and sweet cream buttermilk solids as additional serum solids.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
C	5.00	3.13	2.25
D	7.00	2.77	1.80
E	5.60	2.80	2.38
F	7.00	2.87	2.40
G	5.00	3.40	3.20
H	4.42	3.27	2.53
I	4.80	3.57	2.78
J	6.50	3.63	3.00
AVERAGE	5.67	3.18	2.54

Table 9. Minutes to reach maximum overrun of ice cream mixes containing nonfat dry milk solids and sweet cream buttermilk solids as additional serum solids.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
C	11	7	9
D	7	8	7
E	9	8	7
F	8	8	8
G	11	9	8
H	9	8	6
I	9	9	8
J	9	11	9
AVERAGE	9.12	8.50	7.75

Table 10. Drawing temperature of the tested ice cream mixes drawn at 90 per cent overrun.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
	°F	°F	°F
C	24.98	24.35	23.85
D	25.88	24.85	24.76
E	25.41	24.69	24.93
F	25.16	24.72	24.48
G	25.70	25.26	24.37
H	25.59	24.99	24.64
I	25.48	24.82	24.32
J	25.97	24.66	24.80
AVERAGE	25.52	24.79	24.52

Table 11. Percentage maximum overrun obtained from ice cream mixes containing nonfat dry milk solids and sweet cream buttermilk solids as additional serum solids.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
C	116	136	144
D	90	140	150
E	98	150	150
F	92	148	150
G	116	150	150
H	120	148	150
I	104	145	148
J	94	140	148
AVERAGE	104	145	149

Table 12. Flavor scores and criticisms on ice creams during the first and fourth week.

Trials	NFDMS		NFDMS + SCBMS		SCBMS	
	Score	Criticism	Score	Criticism	Score	Criticism
			1st Week			
C	40.0	---	39.5	---	39.5	---
D	40.0	---	40.0	---	39.5	---
E	40.0	---	39.5	---	40.0	---
F	40.0	---	39.5	---	39.5	---
G	40.0	---	40.0	---	39.5	---
H	40.0	---	40.0	---	39.0	1 freshness
I	40.0	---	39.5	---	39.0	1 freshness
J	40.0	---	39.5	---	39.5	---
AVERAGE	40.0	---	39.69	---	39.44	---
			4th Week			
C	40.0	---	40.0	---	39.5	---
D	40.0	---	40.0	---	39.0	1 freshness
E	40.0	---	39.0	1 freshness	39.0	1 freshness
F	40.0	---	39.5	---	39.5	---
G	40.0	---	39.0	1 freshness	40.0	---
H	40.0	---	40.0	---	40.0	---
I	40.0	---	40.0	---	40.0	---
J	40.0	---	40.0	---	39.5	---
AVERAGE	40.00	---	39.69	---	39.56	---

Table 13. Body and texture scores and criticisms on ice creams during the first and fourth week.

Trials	NFDMS		NFDMS + SCBMS		SCBMS	
	Score	Criticism	Score	Criticism	Score	Criticism
			1st Week			
C	29.5	---	30.0	---	30.0	---
D	29.5	---	30.0	---	30.0	---
E	30.0	---	30.0	---	30.0	---
F	30.0	---	30.0	---	30.0	---
G	29.5	---	30.0	---	30.0	---
H	29.5	---	29.5	---	29.5	---
I	29.5	---	29.5	---	30.0	---
J	29.5	---	29.5	---	30.0	---
AVERAGE	29.62	---	29.81	---	29.94	---
			4th Week			
C	29.0	sl.coarse	29.5	---	30.0	---
D	29.5	---	29.5	---	29.5	---
E	29.0	sl.coarse	29.0	sl.coarse	29.5	---
F	29.0	sl.coarse	29.5	---	29.5	---
G	29.5	---	29.5	---	29.5	---
H	29.0	sl.coarse	29.5	---	29.5	---
I	29.0	sl.coarse	29.0	sl.coarse	29.0	sl. coarse
J	29.5	---	29.5	---	30.0	---
AVERAGE	29.19	---	29.38	---	29.56	---

Table 14. Percentage overrun at one minute whipping intervals of the different ice cream mixes tested.

Trials	Minutes Whipping										
	1	2	3	4	5	6	7	8	9	10	11
						1. NFDMS					
C	53	61	70	83	90	96	104	106	110	114	116
D	58	65	69	76	80	86	90				
E	53	65	70	77	87	92	94	96	98		
F	52	60	66	74	80	85	90	92			
G	55	68	72	82	90	98	104	104	109	112	116
H	55	67	74	87	94	102	106	111	120		
I	51	62	72	82	92	98	100	104	104		
J	49	56	65	72	80	88	92	92	94		
						2. NFDMS + SCBMS					
C	57	71	88	103	118	132	136				
D	65	80	93	107	121	128	138	140			
E	63	74	94	108	119	132	145	150			
F	62	77	92	107	121	131	142	148			
G	56	72	84	99	114	125	137	145	150		
H	57	70	84	106	124	133	142	148			
I	56	70	82	96	114	122	135	142	145		
J	56	69	83	94	100	110	119	130	136	138	140
						3. SCBMS					
C	62	86	102	112	126	130	133	140	144		
D	73	94	110	129	138	145	150				
E	66	85	98	108	128	140	150				
F	68	83	100	113	128	140	148	150			
G	60	74	85	109	119	136	148	150			
H	58	76	102	119	133	150					
I	58	75	94	108	119	131	138	148			
J	62	79	90	102	118	132	138	144	148		

Table 15. Temperatures in °F of mixes in the freezer at one minute whipping intervals.

Trials	Minutes Whipping										
	1	2	3	4	5	6	7	8	9	10	11
1. NFDMS											
C	23.36	23.90	24.44	24.80	24.98	25.16	25.34	26.06	26.06	26.42	26.60
D	23.54	24.26	24.44	24.98	25.16	25.70	25.88				
E	23.72	24.08	24.61	24.98	24.98	25.70	26.06	26.24	26.24		
F	23.36	24.08	24.44	24.80	25.16	25.16	25.16	25.70			
G	24.08	24.80	25.16	25.52	25.70	26.06	25.42	26.96	26.96	27.14	27.32
H	24.08	24.44	24.98	25.52	25.70	26.06	26.42	26.60	26.78		
I	24.08	24.44	25.16	25.34	25.52	25.70	26.06	25.60	27.32		
J	23.00	23.90	24.44	25.16	25.34	25.70	26.24	26.60	26.60		
2. NFDMS + SCBMS											
C	23.36	23.72	24.26	24.98	25.16	25.52	25.88				
D	24.08	24.44	24.98	25.52	26.24	26.42	26.60	26.78			
E	23.90	24.26	24.80	25.16	25.70	26.06	26.42	26.60			
F	23.54	24.26	24.80	25.16	25.70	26.24	26.42	26.78			
G	24.26	24.62	24.98	25.70	25.88	26.24	26.42	26.78	26.96		
H	24.08	24.26	24.80	25.52	25.88	26.06	26.24	26.60			
I	23.54	24.26	24.62	24.98	25.34	25.70	26.24	26.42	26.60		
J	23.36	24.26	24.44	24.80	25.16	25.70	26.06	26.24	26.42	26.96	26.96
3. SCBMS											
C	23.18	23.72	24.26	24.80	25.34	25.88	26.06	26.24	26.42		
D	24.62	24.80	25.34	26.06	26.24	26.60	26.78				
E	24.26	24.80	25.16	25.70	26.06	26.42	26.60				
F	23.90	24.26	24.80	25.16	26.06	26.24	26.42	26.78			
G	23.54	23.72	24.26	24.80	25.34	25.70	25.88	26.42			
H	24.08	24.26	24.98	25.34	25.70	26.06					
I	23.36	23.96	24.44	25.16	25.70	25.88	26.24	26.42			
J	23.54	24.26	24.80	25.16	25.70	26.06	26.42	26.60	26.96		

Table 16. Draw-Rite readings at one minute whipping intervals.

Trials	Minutes Whipping 1	2	3	4	5	6	7	8	9	10	11
					1. NFDMS						
C	8.0	5.4	3.6	3.2	2.8	2.5	2.3	2.2	2.2	2.0	1.9
D	4.8	3.5	3.0	2.8	2.7	2.5	2.4				
E	6.0	5.7	3.2	2.8	2.7	2.2	2.2	2.0	1.9		
F	6.1	3.8	3.2	3.2	2.6	2.4	2.2	1.9			
G	6.9	4.0	3.5	3.1	2.8	2.5	2.4	2.3	2.1	2.0	2.0
H	7.0	4.4	3.5	3.0	2.5	2.3	2.2	2.1	2.1		
I	5.0	3.5	2.9	2.5	2.3	2.1	2.0	1.9	1.8		
J	7.4	4.0	3.1	2.8	2.5	2.2	2.0	2.0	1.9		
					2. NFDMS + SCBMS						
C	9.0	6.6	5.7	3.7	3.4	3.1	2.9				
D	5.0	4.1	3.8	3.1	2.9	2.8	2.7	2.5			
E	6.0	5.0	3.8	3.2	2.9	2.7	2.6	2.5			
F	6.5	4.6	3.8	3.2	2.8	2.7	2.7	2.5			
G	6.7	4.2	3.5	3.1	2.7	2.6	2.5	2.5	2.3		
H	8.5	6.4	5.2	3.7	3.5	3.3	3.1	3.0			
I	6.2	3.9	3.3	3.1	2.9	2.6	2.5	2.4	2.2		
J	6.5	4.1	3.5	3.1	2.9	2.6	2.5	2.4	2.2	2.1	2.0
					3. SCBMS						
C	8.1	5.8	4.4	3.3	2.9	2.6	2.5	2.4	2.4		
D	4.9	4.3	3.5	3.0	2.8	2.6	2.5				
E	6.0	4.0	3.3	2.8	2.7	2.3	2.2				
F	7.1	5.0	4.0	3.4	2.9	2.7	2.6	2.4			
G	9.5	6.2	4.3	3.3	3.0	2.8	2.6	2.4			
H	7.3	5.1	4.2	3.2	2.9	2.7					
I	6.9	4.8	3.5	3.0	2.6	2.5	2.4	2.3			
J	7.0	4.6	3.6	2.9	2.6	2.5	2.4	2.3	2.1		

Table 17. Percentage fat content of ice cream mixes in different trials.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
C	12.38	12.69	12.84
D	12.71	12.76	12.62
E	12.78	13.18	13.18
F	13.11	13.08	13.22
G	13.43	13.58	13.32
H	13.58	13.63	13.36
I	12.38	12.58	12.62
J	12.40	12.58	12.41
AVERAGE	12.84	13.01	12.94

Table 18. Percentage total solids content of ice cream mixes in different trials.

Trials	NFDMS	NFDMS + SCBMS	SCBMS
C	37.87	38.07	38.45
D	37.89	38.04	37.56
E	38.10	38.82	38.87
F	38.11	38.81	38.87
G	38.82	38.61	37.96
H	38.69	38.58	38.07
I	37.33	37.74	37.99
J	37.39	37.80	38.06
AVERAGE	38.02	38.30	38.22

Table 19. Data on observations on the use of .2 per cent emulsifier in ice cream mix containing nonfat dry milk solids as additional serum solids.

Items of Observations	Trials	
	1	2
Titratable acidity (%)	.2100	.2125
pH	6.27	6.31
Original viscosity, 54°F (°retardation)	40	38
Apparent viscosity, 54°F (°retardation)	357	335
Basic viscosity, 54°F (°retardation)	74	58
Whipping time (min.)	2.62	2.00
Final overrun (%)	90	90
Temperature when drawn (°F)	24.59	24.80
Conditions when drawn	firm-dry	firm-dry
Flavor scores and criticisms		
1st week	39.50 ---	40.00 ---
4th week	40.00 ---	39.50 ---
Body and texture scores and criticisms		
1st week	29.50 ---	30.00 ---
4th week	29.50 ---	30.00 ---
Melting properties	normal	normal
Appearance of melt-down	sl.whey-off	sl.whey-off

Table 20. Overrun, temperature and Draw-Rite readings in freezing ice cream mixes containing nonfat dry milk solids as additional serum solids plus .2% emulsifier.

	Trials	Minutes Whipping						
		1	2	3	4	5	6	7
Overrun	1	69	80	96	112	124	135	140
	2	70	90	105	120	131	142	
Temperature	1	23.36	24.26	24.80	25.34	25.70	26.06	26.42
	2	24.44	24.80	25.16	25.88	26.24	26.60	
Draw-Rite	1	7.2	4.6	3.4	3.1	3.0	2.7	2.4
	2	8.3	6.4	3.8	3.2	2.9	2.8	

BIBLIOGRAPHY

(1) Anonymous. Laboratory manual. Milk Industry Foundation. Washington, D. C., 1949.

(2) Arbuckle, W. S., C. N. Shepardson, and H. M. Walling. The utilization of skim milk in the ice cream mix. Texas Agr. Exper. Sta. Bul. 656. 1944.

(3) Associates of Rogers, L. A. Fundamentals of dairy science. 2nd ed. New York: The Chemical Catalog Company, 1935.

(4) Bird, E. W., D. F. Breazeale, and G. C. Sands. Chemistry of butter and butter-making. Part 2 - The nature of the fatty materials in buttermilk and the significance of certain buttermilk testing methods. Iowa Agr. Exper. Sta. Res. Bul. 175.1935.

(5) Bird, E. W., and G. C. Sands. The effect of lipins on the fat test of buttermilk. Jour. Dairy Sci. 13:453-460. 1930.

(6) Button, F. C. Constituents of powdered egg yolk influence freezing, demonstrating three specific effects. Ice Cream Rev. 13(4) :60-61. 1929.

(7) Button, F. C. Results in using dehydrated egg yolk, albumin, and whole egg. Ice Cream Trade Jour. 25(8) :37-38. 1929.

(8) Caulfield, W. J., and W. H. Martin. How butter affects whipping. Ice Cream Trade Jour. 25(9) :56-59. 1929.

(9) Carithers, R. L., and W. B. Combs. Drum vs. spray process dry milk in ice cream. Ice Cream Rev. 19:42+. Mar. 1936.

(10) Chapman, O. W. The effect of lecithin in dairy products upon butterfat determinations. Jour. Dairy Sci. 11:429-435. 1928.

(11) Combs, W. B. Powdered buttermilk in ice cream. Ice Cream Rev. 10(9) :79-80. 1927.

(12) Combs, W. B. Drum process dry milk in ice cream. Ice Cream Rev. 26(6) :14. 1943.

(13) Davis, R. N. Some properties of milk powders with particular reference to sweet buttermilk powders. Jour. Dairy Sci. 22:179-189. 1939.

(14) El Rafey, M. S., G. A. Richardson, and J. L. Henderson. The effect of the method of manufacture of butteroil on its keeping quality. Jour. Dairy Sci. 27:807. 1944.

(15) Gortner, Ross Aiken. Outlines of biochemistry. 2nd ed. New York: John Wiley and Sons Inc., 1938.

(16) Hunziker, O. F. Utilization of buttermilk in the form of condensed and dried buttermilk. Jour. Dairy Sci. 7:1-12. 1923.

(17) Hunziker, Otto Frederick. Condensed milk and milk powder. 7th ed. Published by the author. La Grange, Illinois, 1949.

(18) Holm, George E., Phillip A. Wright, and Edgar F. Deysher. The phospholipids in milk. Part 1 - Their distribution among some milk products. Jour. Dairy Sci. 16:445-454. 1933.

(19) Kock, W., and H. S. Woods. The quantitative estimation of the lecithins. Jour. Biol. Chem. 1:203-211. 1906.

(20) Leighton, Alan, and Abraham Leviton. The relationship between temperature and overrun in the whipping of ice cream mixes. Jour. Dairy Sci. 20:371-378. 1937.

(21) Leighton, Alan, and Abraham Leviton. The whipping capacity of ice cream mixes. Ind. Eng. Chem. 31:779-783. 1939.

(22) Levene, P. A., and I. P. Rolf. The unsaturated fatty acids of egg lecithin. Jour. Biol. Chem. 51:507-513. 1922.

(23) Martin, W. H., and W. J. Caulfield. The use of egg yolk in ice cream. Jour. Dairy Sci. 12:193-201. 1929.

(24) McDowall, F. H. Sweet cream buttermilk. New Zealand Jour. Sci. Tech. 28(2) :97-132. 1946.

(25) Mojonnier, Timothy, and Hugh Charles Troy. The technical control of dairy products. 2nd ed. Chicago: Mojonnier Bros. Co., 1925.

(26) Mueller, W. S., and F. C. Button. The use of dehydrated egg products in the manufacture of ice cream. Jour. Dairy Sci. 12:320-334. 1929.

(27) Osborne, T. B., and A. J. Wakeman. Some new constituents of milk. First paper. The phosphatides of milk. Jour. Biol. Chem. 21:539-550. 1915.

(28) Osborne, T. B., and A. J. Wakeman. Some new constituents of milk. Second paper. The distribution of phosphatides of milk. Jour. Biol. Chem. 28:1-9. 1916.

(29) Palmer, L. S. E. Samuelson, and H. F. Wiese. Substances absorbed on the fat globules in cream and their relation to churning. II The isolation and identification of absorbed substances. Jour. Dairy Sci. 16:41-57. 1933.

(30) Penczek, E. S., and A. C. Dahlberg. Further observations on basic viscosity of ice cream mixes and a simplified procedure to obtain it. Jour. Dairy Sci. 23:691-700. 1940.

(31) Price, W. V. The influence of sweetened frozen cream on the development of swelling in ice cream. Jour. Dairy Sci. 14:221-228. 1931.

(32) Ricciardi, A. The status of ice cream standards. Ice Cream Trade Jour. 44(12) :40. 1948.

(33) Sommer, Hugo H. The theory and practice of ice cream making. 5th ed. Published by the author. Madison, Wisconsin, 1947.

(34) Supplee, G. C., and B. Bellis. Solubility of milk powder as affected by moisture content. Jour. Dairy Sci. 8:39-46. 1925.

(35) Supplee, G. C. The lecithin content of butter and its possible relationship to the fishy flavor. N. Y. Agr. Exper. Sta. (Cornell) Memoir 29. 1919.

(36) Thomas, E. L., and W. B. Combs. Observations on the use of roller process sweet cream buttermilk powder in ice cream. Jour. Dairy Sci. 27:419-432. 1944.

(37) Tracy, P. H. Meeting problems in ice cream manufacture under war time restrictions. Ice Cream Rev. 27(11) :22. 1944.

(38) Tracy, P. H., and H. A. Ruehe. Recent studies in ice cream manufacture. Ice Cream Rev. 14(8) :54-55. 1931.

(39) Thurston, L. M., and J. L. Barnhart. A study of the relation of materials absorbed on the fat globules to the richness of flavor of milk and certain milk products. Jour. Dairy Sci. 18:131-141. 1935.

(40) Thurston, L. M., and W. E. Petersen. Lipins and sterols as sources of error in the estimation of fat in buttermilk. Jour. Dairy Sci. 11:270-283. 1928.

(41) Walts, C. C. and C. D. Dahle. The effect of egg products on the whipping properties of ice cream mixes made from butter and dried skim milk. Jour. Agr. Res. 47:967-977. 1933.

(42) Whitaker, Randall. The influence of the use of butter on the freezing properties of ice cream mix. Jour. Dairy Sci. 13:1-7. 1930.

(43) Williams, D. H., F. E. Potter, and C. F. Hufnagel. Concentrated buttermilk in ice cream. Jour. Dairy Sci. 33:593-598. 1950.

(44) Wright, Philip A., and George E. Holm. The phospholipids in milk, Part 2 - The phospholipids in skim milks and their effect upon the accuracy of various fat tests. Jour. Dairy Sci. 16:455-459. 1933.

(45) Wright, Philip A., Edgar F. Deysher, and George E. Holm. The phospholipids in milk. Part 3 - The phospholipids in buttermilk and their effect upon the accuracy of various fat tests. Jour. Dairy Sci. 16:460-466. 1933.