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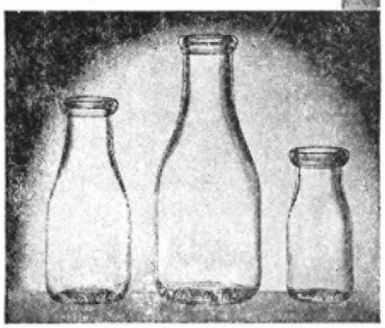

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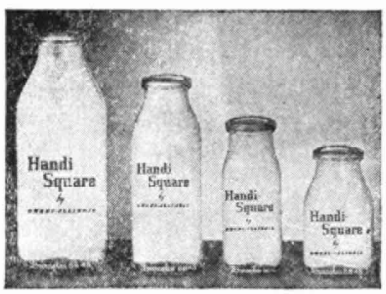

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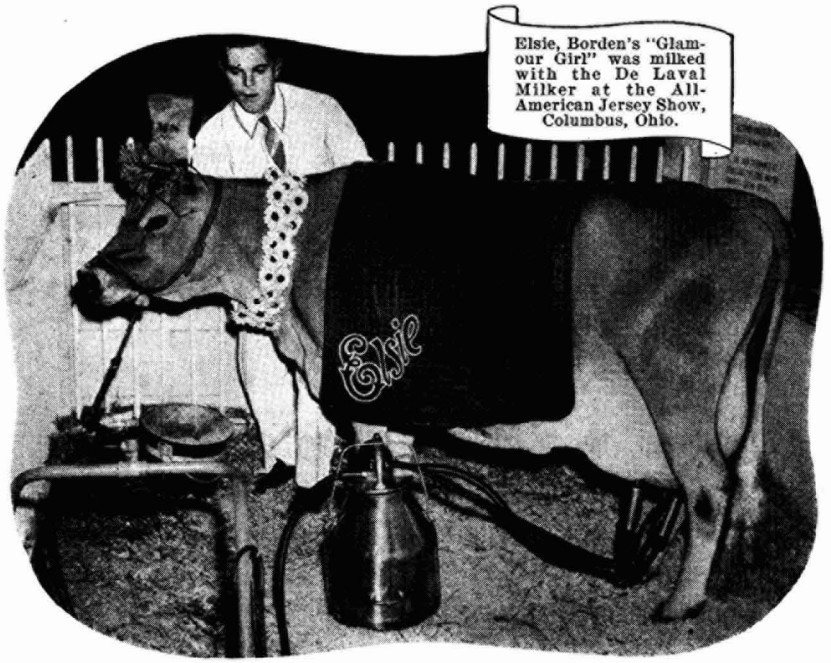

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COMPARISON OF SUCROSE, HIGH CONVERSION CORN SIRUP, AND DEXTROSE IN THE PRESERVATION OF PEACHES BY THE FROZEN-PACK METHOD FOR USE IN ICE CREAM

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The use of frozen-pack fruits in the ice cream industry has been gaining in popularity in recent years. This has been due largely to the superior flavor of the frozen fruit as compared with the canned. The favorable experiences with frozen foods gained during World War II undoubtedly will place even greater emphasis upon the method of preserving and transporting fruits in frozen form.

While many ice cream manufacturers prepare much of their own pack of peaches, a considerable portion of their supply is purchased from commercial dealers. The peeled peaches are sliced or made into puree and mixed with sugar (cane or beet) in varying proportions, though three parts of fruit to one part of sugar commonly is used. This mixture then is placed in containers, rapidly frozen and stored at temperatures below zero degrees Fahrenheit until used. The sugar shortage during World War II, however, made it important that some consideration be given to the use of other types of sweetening agents, such as dextrose (corn sugar) and corn sirup, in the preparation of frozen fruit to be used in ice cream.

PROCEDURE

The studies were made during late 1941 and early 1942. The fruit was obtained from the peach-breeding plots of the University of Illinois experimental farms at Olney, Illinois, and represents the 1941 crop. The types chosen for study, as listed in table 1, are eight of the most promising selections in the Station peach-breeding project. Observations were made of the flavor, degree of ripeness, and texture of the fruit when received. The peaches were immersed in boiling water for a period of 30 seconds, followed by dipping into cold water. After the fruit skins were removed and the

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peaches halved and stoned, the fruit was immersed in ice water until packing, which was accomplished within 1 hour after the hot-water immersion.

The fruit was packed in pint paper cartons, using various combinations and types of sugar. Immediately after packing, the cartons were placed in a 40° F. room for a period of 2 hours; the fruit was shaken at intervals to aid in the blending of sugar and fruit. The cartons of fruit then were stored at a temperature of approximately −2° to −20° F. for periods of 4 to 8 months. At the end of the storage period, the samples were removed to a 40° F. room and permitted to thaw slowly, after which they were judged for color, flavor, texture, and sugar crystallization.

TABLE 1

Varieties, flavor and degree of ripeness of peaches when packed

Variety (cross)	Flesh color	Quality	Acid*	Degree of ripeness	Date ripe
Heath × Marigold–K	White	Good	.....	Slightly green	Aug. 5
Heath × Marigold	White	Good	.....	Slightly green	Aug. 4
J. H. Hale × Gage–K50	Yellow	Good	1.65	Slightly green	Aug. 15
Elberta × Ea. Elberta	Yellow	Very good	0.48	Well ripened	Aug. 22
J. H. Hale × Gage	Yellow	Very good	0.76	Well ripened	Aug. 22
Gage × Elberta	Yellow	Excellent	0.63	Very ripe	Aug. 21
J. H. Hale × Elberta	Yellow	Good	0.72	Well ripened	Aug. 28
Elberta × Southhaven	Yellow	Good	0.49	Very ripe	Sept. 1

* Data on acid content supplied by Dr. R. V. Lott. Values represent percentage malic acid in the fruit juice.

Cane sugar, enzyme converted corn sirup,[3] and dextrose hydrate were the sweetening agents used in the preparation of the experimental packs.

EXPERIMENTAL RESULTS

Heath × Marigold–K

This variety of peach is white. It was packed using fruit-sugar concentrations of (2+1), (2.5+1), and (3+1). The following combinations of sweetening agents were used in the three concentrations listed above:

1. 100 per cent sucrose
2. 100 per cent dextrose
3. 100 per cent enzyme converted corn sirup
4. 25 per cent sucrose plus 75 per cent dextrose
5. 50 per cent sucrose plus 50 per cent dextrose
6. 75 per cent sucrose plus 25 per cent dextrose
7. 25 per cent sucrose plus 75 per cent corn sirup
8. 50 per cent sucrose plus 50 per cent corn sirup
9. 75 per cent sucrose plus 25 per cent corn sirup
10. 25 per cent dextrose plus 75 per cent corn sirup

[3] This product will be referred to as corn sirup, and contained approximately 18% moisture, 10% dextrins, 41% maltose and higher sugars, and 31% dextrose.

11. 50 per cent dextrose plus 50 per cent corn sirup
12. 75 per cent dextrose plus 25 per cent corn sirup

The peaches were slightly green but had a fair flavor when packed. The fruit was judged after approximately 5 months of storage.

The (2+1), (2.5+1), and (3+1) packs were placed in that order when judged for color. Of the packs prepared with a single type of sweetening agent, the sucrose samples had the best color, the packs prepared with corn sirup were second best, and the dextrose samples had the least desirable color, being very brown. The color of the peaches using the different combinations of sucrose and corn sirup was about the same, though some preference was shown for those packs prepared with 50 per cent corn sirup and 50 per cent sucrose in a concentration of two parts of fruit to one part of sugar.

The best-flavored packs were the (2+1), (2.5+1), and (3+1) in that order. Of the packs prepared with a single sweetening agent, the sucrose-packed fruits were best, the corn sirup packs were second best, and the dextrose-packed samples were third. Considering all lots, the samples having the best flavor contained 50 per cent corn sirup plus 50 per cent sucrose in a concentration of two parts of fruit to one part of sugar.

Dextrose was most soluble in the (3+1) packs. It was less soluble in combination with corn sirup than with sucrose. There was evidence of crystallization of the dextrose in all of the corn sirup and dextrose combinations.

Heath × Marigold

This variety of peach was packed using fruit-sugar concentrations of (2+1), (2.5+1), and (3+1). The same combinations of sucrose, dextrose, and corn sirup were used as in the previous experiment.

The (2+1), (2.5+1), and (3+1) packs were placed in that order when judged for color. The corn sirup pack had the best color of all lots containing a single sweetening agent, followed by the sucrose pack and the dextrose pack. The all-dextrose pack was very brown. The colors of the peaches in combinations of corn sirup and sucrose were about the same except the 50 per cent sucrose and 50 per cent corn sirup sample in a (2.5+1) concentration, which was the best of all packs, followed by the same sweetening agent combination in a (2+1) pack.

The best-flavored packs were the (2+1), (2.5+1), and (3+1), in that order. Of the packs containing a single sweetening agent, the sucrose-packed fruits were best, followed by corn sirup and dextrose sugar packs in the order named. The best-flavored fruit of the entire pack was the 75 per cent sucrose plus 25 per cent corn sirup sample in a (2.5+1) concentration, followed by the sample containing 25 per cent sucrose plus 75 per cent corn sirup in a (2+1) concentration. There was evidence of crystallization in all packs where dextrose was used.

Gage × Elberta

This variety of peach was packed using fruit-sugar concentrations of (2+1), (3+1), and (4+1).

The sweetening agents used in this pack were added in the form of sirup and were compared with samples packed using sugar and corn sirup added on a weight basis as follows:

1. 100 per cent sucrose
2. 100 per cent corn sirup
3. 50 per cent corn sirup plus 50 per cent sucrose
4. 40 per cent corn sirup
5. 50 per cent corn sirup
6. 60 per cent corn sirup
7. 40 per cent sucrose sirup
8. 50 per cent sucrose sirup
9. 60 per cent sucrose sirup
10. 20 per cent sucrose sirup plus 20 per cent corn sirup
11. 25 per cent sucrose sirup plus 25 per cent corn sirup
12. 30 per cent sucrose sirup plus 30 per cent corn sirup

These peaches were very ripe and had an excellent flavor when packed. The fruit was judged after 4 months of storage.

The (2+1), (3+1), and (4+1) packs were placed in that order when judged for color. In those samples packed with sirup, the best-colored fruits were obtained using sirups of high sugar concentrations. Of the samples containing a single sweetening agent, the sucrose pack had the best color, followed by the 100 per cent corn sirup pack. Both packs were of excellent color, however.

The best-flavored packs were those of a (2+1) concentration, followed by the (3+1) and the (4+1) packs. The (4+1) packs all were bitter. The all-sucrose pack had the best flavor, followed by the 50 per cent sucrose plus 50 per cent corn sirup pack, which was second, and the 100 per cent corn sirup pack, which was third. Of the packs using sirup, the best-flavored samples were prepared with sirups of high (60 per cent) sugar concentration.

J. H. Hale × Gage

This variety of peach was packed using fruit-sugar concentrations of (1+1), (2+1), (3+1), and (4+1). The sweetening agents used were added in the form of a 50 per cent sirup and were compared with both dry sucrose and 100 per cent corn sirup as follows:

1. 100 per cent sucrose—dry
2. 100 per cent corn sirup

3. 50 per cent corn sirup plus 50 per cent sucrose (heated to boiling and cooled before adding to peaches)
4. 50 per cent corn sirup plus 50 per cent sucrose (mixed cold before adding)
5. 50 per cent corn sirup plus 50 per cent sucrose (mixed as added to peaches)

These peaches were well ripened when packed and had a good flavor. The fruit was judged after 5 months of storage.

The pack in general had a good appearance, with the color becoming slightly less desirable as the concentration of sugar sirup decreased. The all-sucrose pack had the least desirable color. The (1 + 1) pack resulted in a slightly pulped fruit. All of the samples lacked flavor, with no distinct differences noticeable. In general the pack was not satisfactory.

Elberta × Early Elberta

This variety of peach was packed using fruit-sugar concentrations of (1 + 1), (2 + 1), (3 + 1), and (4 + 1). The sweetening agents used were added in the form of sirup or on a dry basis in the following combinations:

1. 100 per cent sucrose—dry
2. 100 per cent corn sirup
3. 50 per cent corn sirup plus 50 per cent sucrose (heated to boiling and cooled before adding)
4. 50 per cent corn sirup plus 50 per cent sucrose (mixed cold before adding)
5. 50 per cent corn sirup plus 50 per cent sucrose (mixed as added)

These peaches were well ripened and had an excellent flavor when packed. The fruit was judged after 6 months of storage.

The 100 per cent corn sirup packs had the best color, followed by 100 per cent sucrose, and 50 per cent corn sirup plus 50 per cent sucrose combinations. The boiled sirup combinations were the least desirable. The natural fruit color increased with the increase in sugar concentrations throughout the pack.

The body and texture of the peaches became less desirable with a decrease in the sugar concentrations, except the (1 + 1) pack, in which the fruit was pulped and the sugar was crystallized.

The best-flavored groups were the packs containing 50 per cent sucrose plus 50 per cent corn sirup, mixed before adding, followed by the packs prepared with 100 per cent corn sirup, 100 per cent sucrose, and 50 per cent corn sirup and 50 per cent sucrose mixed as added. The boiled sirup samples were the least desirable. The intensity of the fruit flavor increased with the increased sugar concentrations. The best individual sample was

the (1 + 1) pack using 100 per cent corn sirup, followed by the (2 + 1) concentration prepared with 100 per cent sucrose, and the sample containing 100 per cent corn sirup in a (3 + 1) pack.

The same results were obtained using the same types of packs with a J. H. Hale and Gage-K50.

Elberta × *Southhaven*

These peaches were packed in 1-gallon paper containers using fruit-sugar concentrations of (2 + 1), (3 + 1), and (4 + 1). The sweetening agents used were 80 per cent sucrose sirup, 80 per cent corn sirup, and 70 per cent corn sirup.

The fruit was well ripened when packed and had an excellent flavor.

The different packs all were judged to be excellent in color with no distinct difference in appearance. All samples also rated excellent in flavor, with the (2 + 1) pack using 80 per cent sucrose sirup best, the (2 + 1) 70 per cent corn sirup pack second, and the (3 + 1) 80 per cent corn sirup pack last.

J. H. Hale × *Elberta*

This variety of peach was packed using fruit-sugar concentrations of (2 + 1), (3 + 1), and (4 + 1). The sugars used in this pack were added in the form of sirup or on a dry basis in the combinations given below:

1. 100 per cent sucrose
2. 100 per cent corn sirup
3. 50 per cent corn sirup plus 50 per cent sucrose
4. 40 per cent corn sirup
5. 50 per cent corn sirup
6. 60 per cent corn sirup
7. 40 per cent sucrose sirup
8. 50 per cent sucrose sirup
9. 60 per cent sucrose sirup
10. 40 per cent sirup—half sugar and half corn sirup
11. 50 per cent sirup—half sugar and half corn sirup
12. 70 per cent sirup—57 per cent sugar and 43 per cent corn sirup

These peaches were ripe and had a good flavor when packed. The fruit was judged after 4 months of storage.

The (2 + 1), (3 + 1), and (4 + 1) packs were placed in that order when judged for color. The best colors were evident when sirups of high sugar concentrations were used. Of the lots containing a single sweetening agent, the corn sirup pack was considered to have a better color than the sucrose pack. In the packs containing sucrose plus corn sirup combinations, there was little difference in the color of the various samples.

The best-flavored samples were the (2 + 1) packs, followed by (3 + 1) and (4 + 1) packs. The all-sucrose packs had the best flavor, followed by the 50 per cent sucrose plus 50 per cent corn sirup packs, and the all-corn sirup packs. The flavors of the peaches packed with different concentrations of sirups improved with the increase of total solids in the sirup used.

DISCUSSION

Of the varieties of peaches used in this study, the Gage crossed with Elberta proved to be most satisfactory from the standpoint of flavor, color, and body.

In the selection of a peach to be frozen-packed for later use in ice cream, it was found to be important that the fruit be well ripened, firm yet juicy, of golden yellow color and of distinct flavor. High sugar concentrations did not cause as excessive bleeding of the peach as it does in the case of fruits such as the strawberry. The best flavor usually resulted from the use of a high sugar concentration of two parts fruit and one part of sugar (2 + 1); however, satisfactory results were obtained with (3 + 1) packs. Packs containing only 20 per cent sugar (4 + 1) were not satisfactory because of the loss in flavor during storage.

Dextrose, because of its low solubility, crystallized when used alone. In combination with sucrose or corn sirup, little crystallization occurred in (3 + 1) packs when the proportion of dextrose was not greater than 50 per cent.

Corn sirup produced satisfactory results when used to replace 50 per cent of the sucrose. Such combinations were in some cases superior in flavor to the all-sucrose packs. When the corn sirup was used to replace all the sucrose, the flavor usually was considered less desirable.

Better fruit color resulted from the use of a combination of corn sirup and sucrose than when sucrose was used alone.

In comparing the different methods of adding the sugar and sirup to the fruit, it was found that adding the sugar in dry form gave best results. When sugar and corn sirup both were used, adding the fruit, sugar, and sirup in alternate layers was most satisfactory. Inverting of the containers at least once before final storage was found to aid in uniform mixing of the sugar and sirup with the fruit.

CONCLUSIONS

1. Peaches vary a great deal from the standpoint of their desirability for storage in frozen form.

2. Peaches to be frozen-packed should be well ripened, firm, juicy and of a golden yellow color.

3. For best flavor and color, the proportion of fruit to sweetening agent should be (2 + 1).

4. From the standpoint of flavor and color, a combination of 50 per cent cane sugar and 50 per cent corn sirup proved to be most satisfactory.

5. Because of its low solubility, dextrose should not be used in greater proportions than 50 per cent of the sweetening agent used and should not be used in fruit-sugar ratios in which the proportion of fruit to sugar is less than 3 to 1.

6. When using a combination of sugar and corn sirup, the fruit, sugar, and sirup should be added in alternate layers. There is no particular advantage in combining the sugar and sirup before adding to the fruit.

REFERENCE

(1) 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. Agr. Expt. Sta. Bul. 407. 1934.

HERITABILITY OF HEAT TOLERANCE IN DAIRY CATTLE

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Dairy cattle with a high degree of tolerance to heat are especially desirable in southern regions of the United States. Those possessing this heat-tolerance characteristic would be in special demand if they transmitted portions of it to their offspring. Otherwise, little permanent gain would be made in selecting animals possessing a high tolerance to heat.

Previous studies by Freeborn *et al.* (2) and Seath and Miller (9) have shown that Jerseys appear to be more tolerant to heat than do Holsteins. No attempt was made, however, to measure the degree to which heat tolerance is heritable. The present study was undertaken in an attempt to answer that question. It also was conducted in an effort to determine, if possible, what particular type of observation and how many observations should be made in order to best measure heat tolerance in dairy cattle.

MATERIAL AND METHODS

A description of the cows used and the method of securing the data have been covered in a previous paper (8). In brief, the procedure involved taking body (rectal) temperatures and respiration rates (from flank movements) of milking cows soon after they entered the milking barn at appproximately 3:00 p.m. In 1944, records were taken twice weekly over a period of 13 weeks between July 28 and October 24. During 1945, fifteen observations were made between July 16 and August 24.

The cows were handled in two separate dairy units, thus necessitating observations on separate days. Each unit consisted of both Jersey and Holstein cows. In 1944 there were 36 Holsteins and 16 Jerseys, while in 1945 there were 41 Holsteins and 27 Jerseys. Only 13 Holsteins and 8 Jerseys were the same for the 2 years.

RESULTS

Sire progeny rank and repeatability for two years. Body temperature and respiration rate averages for sire progeny groups (table 1) give some evidence that data taken duing one year are a reasonably good indication of what can be expected another year from groups of cows by the same sire.

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[1] Dr. J. L. Lush of Iowa State College gave much help and many suggestions on how best to conduct this study and aided in analyzing the data secured. Dr. G. E. Dickerson of the Regional Swine Breeding Laboratory, Ames, Iowa, also assisted with statistical analyses. G. D. Miller and Dr. L. L. Rusoff of the Dairy Research Department, Louisiana State University, assisted in gathering the data and gave valuable suggestions in preparation of manuscript.

In 1944 records were averaged on 52 daughters of 7 sires, the number of daughters varying from 4 to 11 per sire. During 1945 the number of daughters by these same 7 sires, plus one new one, totaled 68 and varied from 4 to 17 per sire with only 21 of them being the same as those observed in 1944.

The relative ranks of the respective sire progeny groups are much the same for the 2 years, with body temperature ratings more nearly alike than those for respiration rate. Of special interest are the high ratings on the basis of average body temperature for Holstein groups, with Jersey groups sharing the top ratings on the basis of respiration rate. It will be noted that daughters of Jersey sire no. 7 ranked highest in respiration rate for each of the 2 years, with over 100 respirations per minute. In contrast, the

TABLE 1

Body temperature and respiration rate averages and rank of sire progeny groups
(Progeny of 7 sires, using data on 8 warmer days)*

Sire no.	Breed	Body temperature				Respiration rate per minute			
		Av.		Relative rank		Av.		Relative rank	
		1944	*1945*	*1944*	*1945*	*1944*	*1945*	*1944*	*1945*
1	Holstein	104.27	104.26	2	2	79.0	81.5	7	5
2	"	104.19	103.91	3	3	81.6	86.3	3	4
3	"	103.79	103.89	4	5	88.2	94.2	2	2
4	"	104.40	104.26	1	1	79.2	80.0	6	7
5	Jersey	103.18	103.16	5	7	79.5	80.7	4	6
6	"	102.91	103.90	7	4	79.3	92.9	5	3
7	"	103.09	103.51	6	6	100.2	100.9	1	1

* Air temperature averaged approximately 89° F. for 8 days observed.

daughters of this same sire ranked sixth for each of the 2 years on the basis of body temperature. In reverse order, the progeny of Holstein sire no. 4 ranked highest in body temperature for both years; yet, on the basis of respiration rate, they ranked sixth in 1944 and seventh in 1945. Likewise, the progeny of sire no. 1 ranked second highest in body temperature each year, yet were seventh and fifth, respectively, in respiration rate for the 2 years.

Correlation coefficients between the average records for the 8 warm days in 1944 with those for 1945 were computed for the 21 cows common to the study for both years. Results of this study, when considered on an intra-breed-herd basis, yielded r values of 0.37 for body temperature and 0.64 for respiration rate. This shows that cows tend to react to warm weather in a given year similarly to the way in which they reacted the previous year.

The use of components of variance in the analysis. Analysis of variance (10) was used to segregate differences (a) between herds (included differences between days on which herds were observed), (b) between breeds within herds, (c) between sires within same breed and herd, (d) between

cows within same sire, breed, and herd group, and (e) between records of the same cow. An example of this method of segregating portions of the total variance can be seen in table 2. The procedure used in deriving an estimate of heritability of heat tolerance and the repeatability between single records of the same cow also is shown. This procedure involved, in principle, the computing of intra-class correlations (10)—in one case that between single records of paternal sisters, which was multiplied by 4 in order to secure an estimate of heritability of differences between single records (4), and in the second case that between single records of the same cow, which gave an estimate of average repeatability of single records (5).

TABLE 2

Analysis of variance for body temperature
(Data for milking cows observed on 8 warmer days in 1944)

Source of variance	*d.f.*	Mean square	Composition of mean square
Between herds	1	7.53	.....
Between breeds within herds	2	45.65	.....
Between sires within herd and breed	10	2.296	$E + cC + sS$
Between cows within sire, herd, and breed	38	1.43	$E + cC$
Between records of same cow	364	0.688	E

E = Variance between records of same cow = 0.688

c = Number of records per cow = 8

s = Computed number of records per sire group (4) = 28.32

C = Variance between cows within same sire, breed, and herd = $\frac{(E + cC) - E}{c} = \frac{1.43 - 0.688}{8}$ = 0.0927

S = Variance between sires within same breed and herd = $\frac{(E + cC + sS) - (E + cC)}{s} = \frac{2.296 - 1.43}{28.32}$ = 0.0306

Repeatability between single records of the same cow = $\frac{C + S}{E + C + S} = \frac{0.0927 + .0306}{0.688 + 0.0927 + 0.0306}$ = 0.152

Estimate of heritable portion of the variance = $\frac{4S}{E + C + S} = \frac{(4)\ 0.0306}{0.688 + 0.0927 + 0.0306}$ = 0.151

Days selected for measuring heat tolerance. A preliminary study was made to determine whether data for all test periods should be used for each year as a measurement of heat tolerance or whether data showing reactions of cows during the warmer days only would give the most accurate information. To determine this answer it was necessary to compare the repeatability of individual cow records when all data were used to that computed using the 8 warmer days, as shown for 1944 in table 2. These comparisons, as given in table 3, show in all cases that body temperature and respiration reactions tended to repeat themselves more closely on the 8 warm days than during the entire test periods. It is probable that this took place because

TABLE 3

Comparison of repeatability of single records of same cow for 8 warmer days versus entire period of test

	Using entire test period		Using 8 warmer days	
	1944	1945	1944	1945
Air temperatures for test periods				
Range	65–93	75–91	86–93	87–91
Average	85	86	89	89
Repeatability of single records				
Body temperature	0.080	0.067	0.152	0.385
Respiration rate	0.254	0.167	0.42	0.478

of the threshold effect, which causes cows to react differently and more as individuals when air temperatures rise above a certain level.

Data for the 8 warmer days also were the most useful in estimating the degree to which heat tolerance is heritable. As with repeatability between single records, it was found that the higher air temperatures as they existed on the 8 warmer days tended to increase the portion of the variance attributable to differences in heredity by from two to four times that found when data for all observation days were considered.

Heritability of body temperature changes. Analysis of the 1944 data for body temperature taken on the 8 warmer days is presented in table 2. Data taken in 1945 have been subjected to the same analysis. Results for the two years are shown in table 4. In general, it appears that the year 1945 produced greater variations that were attributable to differences between cows. As evidence of this, the repeatability between single records of the same cow was 0.385 or 38.5 per cent for 1945 as compared to 15.2 per cent for 1944.

Repeatability and heritability of respiration rate. When the analysis of variance procedure was applied to the respiration data taken on the 8 warmer days, the results (table 5) gave an estimate of repeatability. As shown in table 5, the repeatability in 1945 between records of the same cow was 0.481 or 48.1 per cent. The corresponding value for 1944 was 42 per

TABLE 4

Two-year comparisons of portions of variance concerned with heritability of body temperature

	1944	1945
C = Variance between cows of same sire, breed and herd	0.0927	0.2030
S = Variance between sires within same breed and herd	0.0306	0.0508
$\frac{C+S}{E+C+S}$ = Repeatability between single records of same cow	0.152	0.385
$\frac{4S}{E+C+S}$ = Estimate of heritable portion of variance	0.151	0.309

cent. The estimates of heritable portions of variance were surprisingly high, *i.e.*, 84.3 per cent for 1945 and 76.6 for 1944.

TABLE 5

Analysis of variance for respiration rate
(Data for milking cows observed on 8 warmer days in 1945)

Source of variance	*d.f.*	Mean square	Composition of mean square
Between herds	1	123.0	.....
Between breeds within herds	2	504.5	.....
Between sires within herd and breed	12	2444.5	$E + cC + sS$
Between cows within sire, herd and breed	52	743.8	$E + cC$
Between records of same cow	473	143.8	E

E = Variance between records of same cow	= 143.8
c = Number records per cow	= 8
s = Computed number records per sire group	= 29.12
C = Variance between cows within same sire, breed, and herd	= 75.00
S = Variance between sires within same breed and herd	= 58.40
Repeatability between single records of the same cow	= 0.481
Estimate of heritable portion of the variance	= 0.843

DISCUSSION

Similarity between the ratings in 1944 and 1945 of seven sires on the basis of the response of their daughters to warm weather was quite striking (table 1). These ratings, on the bases of both body temperature and respiration rate, were enough alike for the 2 years to suggest that inheritance must play an important part in causing differences to exist in heat tolerance among dairy cows. Discrepancy between the ratings on the basis of respiration rate as compared to those for body temperature, however, leaves doubt as to the emphasis that should be placed on each of the two heat-tolerance measurements. As was pointed out, the progeny of certain sires ranked near the top in respiration rate, yet near the bottom in body temperature, with the reverse true in one or two cases. This took place even though studies show (3, 8) that both body temperature and respiration rate are correlated closely with air temperature. It would seem that body temperature is probably the safer index on which to judge heat tolerance, since this is no good reason for wanting cows to have high body temperatures. On the other hand, the inheritance of fast breathing by a cow may aid her considerably in quickly eliminating excess heat, which contributes to her comfort (and possibly her health) by more nearly maintaining a normal body temperature.

Repeatability between the averages of warm-weather records for consecutive years among cows of the same breed, based on only 21 cows common to the study for the 2 years, was highest for respiration ($r = 0.64$) and lowest for body temperature ($r = 0.37$). In the case of both respiration and body temperature, these results show that the cow as an individual reacts to warm weather in a manner which is similar from year to year and suggests

that the reason for the similarity in reactions must be due, at least partially, to inheritance.

Results of this study are in line with findings by Regan and Freeborn (7) and the general practice of making heat-tolerance observations on warm days only. When 8 warm days were used, the individual records of each cow show repeatability averages for body temperature of 15.2 per cent and 38.5 per cent, respectively, for the 2 years. For respiration rate the repeatability was higher, being 42 per cent and 47.8 per cent, respectively.

Efforts to estimate heritability of individual body temperature records on the basis of sire-progeny differences, although subject to much sampling error, gave results which appear reasonable, *i.e.*, 15.1 per cent in 1944 and 30.9 per cent in 1945. These are approximately the same as the 15.2 per cent and 38.5 per cent which represent the estimates for repeatability of individual records of the same cow for these 2 years. In general, one would expect the repeatability percentage to exceed that for heritability (5), for a cow tends to repeat her performance, not only because of her specific inheritance but also because of certain factors peculiar to herself, including those involved in her environment.

If 15 to 30 per cent is a reasonable estimate of heritability, then one can closely predict what progress can be made through breeding toward more tolerance to high air temperature. For example, if selection in a herd results in saving, as parents, cows (and a bull) that average 1° F. lower in body temperature (when tested on a warm day) than the average of the entire herd, then one would expect offspring from these selected parents to average from 0.15 to 0.3° F. lower than the herd average when subjected to a similar test. This degree of heritability is in line with that found when considering single production records of dairy cows (5, 6). In both cases, as explained by Lush (5), the use of more than one record increases the heritable portion of the variance, although it does lower slightly the spread between the average of those saved and the average for the herd, which is spoken of as the selection differential. Even so, the increase is worthwhile. Using two records with an average heritability of 20 per cent would increase progress from selection by 29 per cent over that secured when only one record is used. The increase would be 58 per cent using four records, and 83 per cent when eight records are used.

Mention already has been made of the unexpected results secured from a study of respiration rates. The estimates for heritability of 76.6 per cent for 1944 and 84.3 per cent for 1945 greatly exceed those for repeatability of single records, which were 42 per cent and 48.1 per cent, respectively, for these 2 years. In general, one can expect repeatability percentages to exceed those for heritability for reasons already explained in connection with body temperature comparisons. Cases where this does not occur can be explained by sampling errors, *e.g.*, calculation of fiducial

limits for heritability[2] indicates that results secured are well within the range of expectation, considering number of animals tested and number of sires involved in the estimates.

In general, this experiment has yielded results which indicate that respiration rate as a measure of tolerance to heat, while highly repeatable, gives results which are hard to explain and does not appear to coincide closely enough with body temperature as a measurement to permit general use of respiration rate, to the exclusion of other tests. On the other hand, body temperature, while slightly less repeatable, does appear to be a good test for heat tolerance and yields results which are reasonable.

SUMMARY

Tests of Jerseys and Holsteins involving 52 cows by 7 sires in 1944 and 68 cows by 8 sires in 1945 with respect to the heritability of heat tolerance as indicated by variations in body temperature and respiration rate gave results as follows:

1. Ranking of sire progeny by years showed a great similarity for the 2 years, although there was discrepancy between rank on basis of body temperature and that for respiration rate. Some sire groups ranked high on one basis and low on the other and vice versa.

2. Twenty-one cows included in study for both years showed correlations between average records for 8 warmer days (on an intra-herd-breed basis) of 0.37 for body temperature and 0.64 for respiration rate.

3. Using records for 8 warmer days gave a repeatability for individual body temperature records of same cow of 15.2 per cent for 1944 and 38.5 per cent for 1945, as compared to 8 per cent and 6.7 per cent for the 2 years when all observation days were used. In like manner, respiration rates were more highly repeatable using only the warmer days.

4. Estimates of heritability of individual records based on sire-progeny differences were for body temperature 15.1 per cent and 30.9 per cent for the 2 years, and for respiration 76.6 per cent and 84.3 per cent. Figures for respiration appear out of line, as they greatly exceed the estimates of repeatability and the reverse condition was expected.

5. Body temperature appears to be a safer measuring stick for heat tolerance than does respiration rate.

6. The estimate of heritability of body temperature (15 to 30 per cent) is in line with that found for individual production records of cows. In practice this would mean that the offspring from parents selected because of their tolerance to heat would be expected to retain from 15 to 30 per cent of the advantage that the parents had over the average for the herd or breed.

[2] Fiducial limits at the 5 per cent level of significance computed as per methods outlined by Fisher (1) resulted in estimates of heritability of single respiration records ranging from 22 to 177 per cent in 1944 and from 25.6 to 232 per cent in 1945.

7. Using more than one record greatly increases progress through selection. If heritable portion of variance between single heat tolerance record is 20 per cent, then progress through selection would increase by 29 per cent using two records, 58 per cent with four, and 83 per cent using eight records.

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A COMPARISON OF THE BABCOCK, GERBER, MINNESOTA, PENNSYLVANIA, AND MOJONNIER METHODS FOR DETERMINING THE PERCENTAGE OF FAT IN HOMOGENIZED MILK[1]

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The general acceptance of homogenized milk today has made imperative a study of the existing methods for testing it for butterfat. Extensive studies have been made by several workers on the various methods of testing nonhomogenized milk for butterfat, but the data are somewhat limited when the methods are applied to homogenized milk.

LITERATURE

The Roese-Gottlieb (Mojonnier) Method

Burr (6), comparing several methods for testing homogenized milk for fat, found the Roese-Gottlieb method the most accurate. This test was so considered by all the chemists at that time. Richmond (28) pointed out that for ease and accuracy the Roese-Gottlieb method appeared to be the best method for determining the percentage of fat in homogenized milk. Marquardt (23) stated that ether extraction methods gave the most reliable results when testing homogenized milk for fat. Doan (12) stated that the homogenization process did not influence the accuracy of the Roese-Gottlieb or the Mojonnier methods. Mojonnier (25) reported the results of nine tests made by the Kohler and Kohler Laboratories showing that homogenized milk tested by the Mojonnier method averaged 0.012 per cent less than the same milk not homogenized. Dahlberg, Holm, and Troy (11), in comparing the Roese-Gottlieb tests of milk made by five different laboratories, double homogenized one sample at 2,500 lbs. pressure to render it homogeneous for all laboratories. The sample of homogenized milk did not yield tests with the least variation between duplicates or between laboratories.

The Babcock Method

The literature on the Babcock method for testing homogenized milk has been reviewed by Herreid (15) and by Trout and Lucas (34) and need not be repeated in full here. However, some review seems necessary to point out the relationship of the procedure in question with the Mojonnier method.

Nonhomogenized milk. Dahlberg (9) showed, in a comparison of 32 tests of nonhomogenized milk varying in fat content from 4.42 to 4.92 per cent, the Babcock test to be an average of 0.1 per cent high, reading from

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the bottom of the lower meniscus to the extreme top of the upper meniscus. Phillips (27) on 50 trials observed that the Babcock tests of nonhomogenized milk ranged from 0.005 to 0.126 and averaged 0.0588 per cent higher than the Roese-Gottlieb tests. Wilster and Robichaux (36) found in testing 1,380 samples that the Babcock test of nonhomogenized milk ranged from 0.074 to 0.077 per cent higher than the Mojonnier tests. They reported no studies on homogenized milk samples.

Hileman *et al.* (18), surveying the literature, reported that twelve of fourteen investigators secured results with the Babcock test on nonhomogenized milk slightly higher than the Mojonnier, the over-all average being +0.076 per cent above that of the Mojonnier. Fahl, Lucas, and Baten (13) found the Babcock tests higher than those for the Mojonnier. Herreid *et al.* (16), in accounting for milk fat, secured results by the Mojonnier method on unpreserved milk which agreed with those obtained by the Babcock method.

On the other hand, some investigators reported lower tests by the Babcock method than by the Mojonnier. Dahlberg (9), although securing higher results by the Babcock method when the fat column was read according to standard technic, nevertheless did secure lower tests when oil was applied to destroy the meniscus. Dahlberg, Holm, and Troy (11) did not verify the results of several previous investigations which tended to show that the Babcock test gave slightly but uniformly higher percentages of fat than the Mojonnier.

Mojonnier and Troy (24) reported data showing that the difference between the Babcock and Mojonnier tests was not constant in one direction but that the Babcock test varied both above and below that of the Mojonnier. Later, Mojonnier (25) reported the results of Babcock tests on nine samples of homogenized milk which averaged 0.072 per cent higher than the Mojonnier tests. Other tests indicated a higher percentage of fat in the fat columns of test of homogenized milk than in those on nonhomogenized milk.

From calculations of the data presented by Babcock (3) in introducing his test, of 30 samples of whole milk tested by the Babcock and gravimetric methods, 15 Babcock tests were above and 15 were below those of the ether-extraction method. The Babcock test results varied from −0.16 to +0.30 per cent from results of the gravimetric procedure. The average tests differed by 0.01 per cent, the Babcock method being higher.

Homogenized milk. Generally the Babcock test of homogenized milk yields results slightly lower than on the same milk not homogenized, being within the 0.1 per cent tolerance for the test. Workers of the Arizona Experiment Station (1) reported comparison of some 30 samples of homogenized milk from different sources, and homogenized at different pressures, indicated that the Mojonnier test was from 11 to 25 per cent higher than the Babcock test. Later (2) they reported data on six trials of milk homogen-

ized from 2,000 to 4,000 lbs. pressure which showed that the Mojonnier test consistently gave results higher than the Babcock and that the difference was believed sufficient to justify a correction when the Babcock method was used for homogenized milk.

Doan (12), using a modified Babcock method, secured results from 0.084 to 0.11 per cent higher than those by the Mojonnier method, the differences being only insignificantly higher than the average in the literature for non-homogenized milk. Lampert and Brandon (21) secured results on homogenized milk within an average of + 0.03 per cent of the Mojonnier results when using the regular Babcock method on unpreserved samples. This was within 0.01 per cent of the Babcock tests on nonhomogenized milk. Homogenized samples preserved with formalin averaged 0.13 per cent less than by the extraction method. They concluded that the regular Babcock procedure gave accurate results on unpreserved homogenized milk, but a lower test when the sample was preserved with formaldehyde. Trout and Lucas (34) reported that many modifications of the Babcock method existed. Averages of results of five trials on each of eleven modified Babcock tests varied from those of the Mojonnier test from − 0.03 to − 0.15 per cent, depending chiefly upon the modification.

Webster (35) observed in four trials on homogenized milk that the Babcock test averaged 0.088 per cent lower than the Mojonnier test. He reported that the variation between the Babcock and Mojonnier methods was affected directly by the size of the fat globules or, more particularly, by the relative number of small fat globules present. He concluded that the statement that the Babcock test over-reads the Mojonnier or gravimetric method by some stated percentage seems of little value unless the size of the fat globules is considered.

The Gerber Method

Nonhomogenized milk. Fisher and Walts (14) found the average variation from the Roese-Gottlieb was ± 0.137 per cent for the Babcock and ± 0.122 per cent for the Gerber method in testing nonhomogenized milk. Both the Babcock and the Gerber tests for milk in 11 instances (68.75 per cent) gave results which were slightly higher than the Roese-Gottlieb. They believed there was no advantage in introducing to the industry another method, the Gerber, which was not more accurate than the Babcock method. Dahlberg, Holm, and Troy (11) and Dahlberg (10), applying the test to nonhomogenized milk, found that the Gerber and Babcock tests were comparable from the standpoint of accuracy but recommended that one good practical test for fat in milk was better than two of equal merit.

Van der Burg (5) compared the Gerber with other fat tests, including the Roese-Gottlieb, on 85 samples of milk. Generally the Gerber gave slightly higher results than the other methods. In 12 samples the Gerber fat values were identical with other values, in 31 samples they were 0.005

to 0.025 per cent higher, and in 24 samples 0.005 to 0.025 per cent lower. Fourteen samples varied ± 0.030 to ± 0.050 per cent and 4 samples ± 0.055 to ± 0.100 per cent.

Homogenized milk. Buttenberg (8) pointed out that the determination of the fat content of homogenized milk by the Adams method, commonly used at that time, could not show results comparable with the Roese-Gottlieb method; even when the extraction was prolonged purposely from 10 to 12 hours, the results were much too low.

Siegfeld (29) used the Gerber method for testing homogenized milk with excellent results, but pointed out that it was necessary in testing homogenized milk by this method to centrifuge 12 minutes instead of the customary 3 minutes. Burr (6), comparing several methods, found that the Gerber method, while fairly satisfactory, gave results which varied with the time of centrifuging. The homogenized milk examined was processed at 60 atmospheres (approximately 900 lbs.) pressure. Average results of 11 trials showed the Gerber test centrifuged 10 minutes varied from the Roese-Gottlieb by ± 0.02 per cent, − 0.08 to + 0.125 per cent being the range of variation.

Richmond (28) found the Gerber test gave good results with homogenized milk, but that "the advent of homogenized milk rendered it necessary to remove the Adams method from the position it had so long occupied as a standard method." Six trials showed that the Gerber test varied + 0.008 per cent from the Roese-Gottlieb tests of the same milk. Istaz and Van Soest (20) observed that the results secured on homogenized milk by the Gerber method were verified by the gravimetric method in many cases.

Hoyberg (19) had difficulty securing results by the Gerber method comparable with those of the Roese-Gottlieb method, even when centrifuging as long as 45 to 60 minutes, or when prolonging the holding time in the water bath after centrifuging. By heating the milk to 60–65° C., holding it 5 minutes and then making the Gerber test, results identical with those obtained by the Roese-Gottlieb method were secured. He advised pouring heated milk directly into the sulfuric acid and amyl alcohol mixture rather than letting it run down the side of the butyrometer. This resulted in an increased amount of heat liberation, which was deemed important in testing homogenized milk. Milk heated to 15° C. increased to 75° C. during its reaction with the sulfuric acid and amyl alcohol. At 25° C. it increased to 82°, at 40° to 86°, and at 45° to 88° C. Milk heated to 60–65° C. would reach a temperature of 105° C. when added to the acid.

Burr and Weise (7) found that the Gerber method gave comparable but slightly higher fat tests of homogenized milk than the Roese-Gottlieb method. However, in using the Gerber test, double centrifuging was necessary. In 18 trials the Gerber method gave results 0.03 per cent higher than the Roese-Gottlieb method. Von Sobbe (30) found the Gerber method very

satisfactory for testing homogenized milk, but noted that centrifuging had to be repeated at least twice, and that the mixture of sulfuric acid and milk plasma had to be clear and transparent. In making the test he warmed the milk to 60–65° C., then cooled it with agitation to remove the disturbing effects of homogenization. Herrington (17) pointed out that the amyl alcohol used in the Gerber test was a possible source of error in the test. The error caused by the test might be 0.1–0.2 per cent or even higher. He recommended that boiling between 128° C. and 132° C. was the best method of identifying any sample of amyl alcohol to be used in making the Gerber test.

The Minnesota-Babcock Method

While the Minnesota-Babcock test is used for the fat determination of all dairy products (26), few data were found in the literature on its use in testing homogenized milk. Trout, Halloran, and Gould (33) and Trout (32) studied the possibilities of the Minnesota reagent for overcoming char formation in testing homogenized milk. They reported results comparable in appearance with the best results obtained by the Babcock method but presented no data comparing the accuracy of the two methods.

Lampert and Brandon (21) on two trials secured tests on homogenized milk by the Minnesota method which ranged from 0.22 to 0.26 per cent less than the Mojonnier tests. The samples were preserved with mercuric chloride. They stated, "Samples preserved with mercuric chloride reacted with the reagent so that a black precipitate, probably finely divided mercury, was formed. This material entered the fat column, but in a number of cases the fat column dropped through this material, leaving it adhering to the neck of the test bottle. Although the fat tests appeared excellent, the results were lower than those obtained with the other procedures (Mojonnier, Babcock, and Pennsylvania), and the use of the Minnesota test was not continued." They concluded that the method could not be recommended for the testing of homogenized milk. Bird and Breazeale (4) observed wide variations in the fat content of the same sample of buttermilk tested by three Minnesota reagents.

The Pennsylvania Method

Few data were found on the use of the Pennsylvania method for testing homogenized milk. Swope (31) recommended it for the testing of homogenized milk. He reported several tests on two samples of homogenized milk, one sample of which showed an average arithmetical deviation from the Mojonnier test of 0.036 per cent and an average algebraic deviation + 0.024 per cent. The second sample showed an arithmetical deviation of 0.047 per cent and an average algebraic deviation of + 0.041 per cent. The range in deviation of the Pennsylvania tests from the Mojonnier tests was from − 0.009 to + 0.091 per cent.

Lampert and Brandon (21) found the Pennsylvania test yielded an average of 0.10 per cent less fat on the homogenized milk than on the same milk not homogenized, the tests of the nonhomogenized and homogenized milk being +0.22 and +0.17 per cent higher, respectively, than those obtained by the Mojonnier method. Difficulty was encountered in making satisfactory tests of homogenized milk to which preservatives had been added. They concluded that the Pennsylvania test could not be recommended for the testing of homogenized milk.

SCOPE OF THE INVESTIGATION

Inasmuch as homogenized milk is of increasing importance in market milk distribution, a comparative study of the various more common methods of testing milk for fat seemed advisable. In this investigation the following methods were compared: Mojonnier, modified Babcock, Gerber, Minnesota-Babcock, Pennsylvania, and a modified Pennsylvania method. Data were secured from duplicate tests on 24 samples for each of the above methods. These tests were not necessarily designed for testing homogenized milk. However, it seemed desirable to include all of them in the study since some of them (a) are more or less common tests in testing laboratories, (b) are used in testing milk in vocational high schools, (c) employ chemicals other than sulfuric acid, which might thus prevent char formation, (d) are readily available, (e) are moderately priced, and (f) are not too difficult for routine analyses.

PROCEDURE

The milk tested was that regularly processed in the College Creamery. The nonhomogenized samples were taken from the vat after pasteurization and prior to homogenization. The milk had been kept thoroughly mixed during pasteurization and homogenization in order to insure uniform fat distribution. The homogenized samples were taken from the cooled bottled product after homogenization was well under way. Mojonnier tests showed that the nonhomogenized and homogenized samples contained similar percentages of fat.

Homogenization was done by means of a 500-gallon-per-hour viscolizer at 2,500 lbs. pressure at 130° to 140° F. following pasteurization. The collected samples were cooled adequately, stored and tested as rapidly as time would permit. Pipetting of the portions of milk into the test bottles was done for all tests at one time to assure correct sampling. This was done after the milk had been tempered at 70° F. for 2 hours. These charged test bottles were then stored at 40° F. until the tests were made.

The Mojonnier test was used as a standard for accuracy. Instead of using an approximately ten-gram portion measured volumetrically, duplicate samples of milk previously tempered at 70° F. were weighed carefully on a chemical balance directly into a fat-extraction flask.

The tests using Babcock test bottles were made in bottles which had been recalibrated for accuracy. Any bottles showing 0.1 per cent or more variation from exact accuracy were discarded. The modified Babcock procedure employed 17.5 ml. of 1.835 specific gravity sulfuric acid added in three portions, 8.0, 5.0 and 4.5 ml., respectively. Mixing was prolonged for at least 2 minutes after final addition of the acid, as suggested by Lucas and Trout (22); however, the water-alcohol solution was not added to support the fat column for reading. The Gerber (Fucoma) test was carried out according to the directions of the Fucoma Company. The reagents used in the Minnesota-Babcock method were from the Kimble Glass Co. The modification of the Pennsylvania test consisted in the use of sulfuric acid having a specific gravity of 1.81 instead of 1.73, as recommended and as used in the regular procedure.

RESULTS

The Mojonnier method. The data secured on testing nonhomogenized and homogenized milk by the Mojonnier method are presented in table 1.

TABLE 1

Mojonnier fat tests of nonhomogenized and homogenized milk

Series*	Mojonnier method						
	Nonhomogenized milk			Homogenized milk			Variation from test of nonhomogenized milk
	Duplicates		Av.	Duplicates		Av.	
	%	%		%	%		
1	3.651	3.650	3.65	3.672	3.671	3.67	+0.02
2	3.708	3.699	3.70	3.701	3.694	3.70	0.00
3	3.695	3.716	3.71	3.712	3.695	3.70	−0.01
4	3.723	3.716	3.72	3.724	3.738	3.73	+0.01
5	3.814	3.801	3.81	3.826	3.817	3.82	+0.01
6	3.831	3.804	3.82	3.804	3.815	3.81	−0.01
7	3.850	3.864	3.86	3.835	3.832	3.83	−0.03
8	3.916	3.886	3.90	3.898	3.882	3.89	−0.01
9	3.897	3.926	3.91	3.918	3.903	3.91	0.00
10	4.375	4.409	4.39	4.407	4.404	4.41	+0.02
11	4.470	4.476	4.47	4.493	4.503	4.50	+0.03
12	4.532	4.537	4.53	4.543	4.552	4.55	+0.02
13	4.585	4.575	4.58	4.560	4.570	4.57	−0.01
14	4.556	4.592	4.57	4.594	4.593	4.59	+0.02
15	4.591	4.589	4.59	4.580	4.600	4.59	0.00
16	4.591	4.596	4.59	4.597	4.586	4.59	0.00
17	4.575	4.628	4.60	4.653	4.634	4.64	+0.04
18	4.619	4.606	4.61	4.608	4.606	4.61	0.00
19	4.606	4.627	4.62	4.641	4.644	4.64	+0.02
20	4.763	4.761	4.76	4.759	4.768	4.76	0.00
21	4.786	4.789	4.79	4.785	4.777	4.78	−0.01
22	4.956	4.973	4.96	4.936	4.934	4.94	−0.02
23	5.012	5.038	5.03	5.049	5.04	5.04	+0.01
24	5.124	5.082	5.10	5.04	5.08	5.06	−0.04
Av.	.....	.....	4.344	.....	.....	4.347	0.0024

* Arranged according to increasing percentages of fat.

The average test was 4.344 per cent for nonhomogenized milk and 4.347 per cent for homogenized milk. Of the 24 samples, 6 tested exactly the same as the nonhomogenized; 8 tested lower, ranging from −0.01 to −0.04 per cent; and 10 tested higher, ranging from +0.01 to +0.04 per cent. Thus it appears that homogenized milk may be tested reliably by the Mojonnier method.

The modified Babcock method. The same samples of milk tested by the Mojonnier method also were tested by the modified Babcock method. The nonhomogenized and homogenized milk averaged 4.402 and 4.390 per cent butterfat, respectively (table 2). Of the 24 samples tested, 10 tests were identical with those of the nonhomogenized milk; 12 were lower, ranging from −0.02 to −0.07; and 2 were higher, +0.02 and +0.05. The nonhomogenized milk averaged 0.057 per cent higher by this method than by the Mojonnier; the homogenized averaged only 0.043 per cent higher.

TABLE 2

Comparison of modified Babcock and Mojonnier tests of homogenized milk

Series*	Modified Babcock method			Variations from Mojonnier	
	Nonhomogenized	Homogenized	Variation of homogenized from nonhomogenized	Nonhomogenized	Homogenized
	%	%			
1	3.72	3.70	−0.02	+0.07	+0.03
2	3.72	3.70	−0.02	+0.02	0.00
3	3.77	3.75	−0.02	+0.06	+0.05
4	3.78	3.78	0.00	+0.06	+0.05
5	3.90	3.88	−0.02	+0.09	+0.06
6	3.85	3.85	0.00	+0.03	+0.04
7	3.90	3.88	−0.02	+0.04	+0.05
8	3.98	3.93	−0.05	+0.08	+0.04
9	3.95	3.93	−0.02	+0.04	+0.02
10	4.48	4.48	0.00	+0.09	+0.07
11	4.53	4.53	0.00	+0.06	+0.03
12	4.58	4.58	0.00	+0.05	+0.03
13	4.63	4.63	0.00	+0.05	+0.06
14	4.67	4.60	−0.07	+0.10	+0.01
15	4.65	4.63	−0.02	+0.06	+0.04
16	4.63	4.63	0.00	+0.04	+0.04
17	4.67	4.65	−0.02	+0.07	+0.01
18	4.70	4.70	0.00	+0.09	+0.09
19	4.68	4.70	+0.02	+0.06	+0.06
20	4.80	4.80	0.00	+0.04	+0.04
21	4.80	4.80	0.00	+0.01	+0.02
22	5.00	4.95	−0.05	+0.04	+0.01
23	5.08	5.13	+0.05	+0.05	+0.09
24	5.17	5.15	−0.02	+0.07	+0.09
Av.	4.402	4.390	−0.012	+0.057†	+0.043†

* The tests reported in this table were included among the data on the 36 trials previously reported by Lucas and Trout (22).

† Highly significantly different from zero.

The Gerber method. The average Gerber tests of the nonhomogenized and homogenized milk were practically identical, the average test on homogenized milk being 0.003 per cent higher (table 3). Of the 24 comparisons, 12 were the same; 5 of the homogenized were lower, ranging from −0.02 to −0.07 per cent; and 7 were higher, ranging from +0.02 to +0.08 per cent. The average tests of both the nonhomogenized and the homogenized averaged

TABLE 3

Comparison of Gerber and Mojonnier tests of homogenized milk

Series	Gerber method			Variations from Mojonnier	
	Nonhomogenized	Homogenized	Variation of homogenized from nonhomogenized	Nonhomogenized	Homogenized
	%	%			
1	3.73	3.73	0.00	+0.08	+0.06
2	3.78	3.78	0.00	+0.08	+0.08
3	3.80	3.80	0.00	+0.09	+0.10
4	3.83	3.83	0.00	+0.11	+0.10
5	3.93	3.95	+0.02	+0.12	+0.13
6	3.85	3.87	+0.02	+0.03	+0.06
7	3.95	3.95	0.00	+0.09	+0.12
8	4.00	4.00	0.00	+0.10	+0.11
9	4.03	3.96	−0.07	+0.12	+0.05
10	4.50	4.52	+0.02	+0.11	+0.11
11	4.60	4.58	−0.02	+0.13	+0.08
12	4.60	4.62	+0.02	+0.07	+0.07
13	4.68	4.68	0.00	+0.10	+0.11
14	4.72	4.70	0.00	+0.15	+0.11
15	4.65	4.67	+0.02	+0.06	+0.08
16	4.70	4.70	0.00	+0.11	+0.11
17	4.68	4.73	+0.05	+0.08	+0.09
18	4.70	4.68	−0.02	+0.09	+0.07
19	4.67	4.75	+0.08	+0.05	+0.11
20	4.85	4.83	−0.02	+0.09	+0.07
21	4.88	4.88	0.00	+0.09	+0.10
22	5.00	4.98	−0.02	+0.04	+0.04
23	5.10	5.10	0.00	+0.07	+0.06
24	5.20	5.20	0.00	+0.10	+0.14
Av.	4.434	4.437	+0.003	+0.090*	+0.090*

* Highly significantly different from zero.

0.09 per cent higher than the corresponding Mojonnier tests. In making the Gerber tests of homogenized milk the following factors were striking: (a) the clarity of the fat column and supporting liquid, (b) the identical reading of the duplicate tests, (c) the consistent check with tests on the nonhomogenized milk, and (d) the complete freedom of any char formation.

The Minnesota method. While the Minnesota-Babcock test of homogenized milk varied from that of the nonhomogenized milk by an average of only +0.027 per cent, the range of variations between the tests extended from −0.32 to +0.40 per cent. Only 2 of the 24 tests were identical with those

of the nonhomogenized milk, while 12 were below, ranging from −0.02 to −0.30, and 10 were above, ranging from +0.07 to +0.40 per cent (table 4). Tests of both nonhomogenized and homogenized milk were consistently under the Mojonnier tests, the tests on the homogenized milk ranging from −0.04 to −0.85 and averaging −0.433 per cent.

The Pennsylvania method. The Pennsylvania tests on homogenized milk consistently were under those of the nonhomogenized milk, −0.07 to −0.72

TABLE 4

Comparison of Minnesota and Mojonnier tests of homogenized milk

Series	Minnesota method			Variations from Mojonnier	
	Nonhomogenized	Homogenized	Variation of homogenized from nonhomogenized	Nonhomogenized	Homogenized
	%	%			
1	3.07	3.35	+0.28	−0.58	−0.32
2	3.08	2.88	−0.20	−0.62	−0.82
3	3.05	3.35	+0.30	−0.66	−0.35
4	3.38	3.28	−0.10	−0.34	−0.45
5	3.25	3.23	−0.02	−0.56	−0.59
6	3.50	3.43	−0.07	−0.32	−0.38
7	3.15	2.98	−0.17	−0.71	−0.85
8	3.22	3.20	−0.02	−0.68	−0.69
9	3.33	3.48	+0.15	−0.58	−0.43
10	4.00	4.07	+0.07	−0.39	−0.34
11	4.23	3.93	−0.30	−0.24	−0.57
12	4.00	4.30	+0.30	−0.53	−0.25
13	4.08	4.40	+0.32	−0.50	−0.17
14	3.95	3.95	0.00	−0.62	−0.64
15	4.30	4.55	+0.25	−0.29	−0.04
16	4.23	4.35	+0.12	−0.36	−0.24
17	4.47	4.15	−0.32	−0.13	−0.49
18	4.05	4.20	+0.15	−0.55	−0.41
19	4.20	3.98	−0.22	−0.42	−0.66
20	4.57	4.45	−0.12	−0.19	−0.31
21	4.20	4.60	+0.40	−0.59	−0.18
22	4.43	4.35	−0.08	−0.53	−0.59
23	4.76	4.76	0.00	−0.27	−0.28
24	4.77	4.70	−0.07	−0.33	−0.36
Av.	3.886	3.913	+0.027	−0.458*	−0.433*

* Highly significantly different from zero.

and averaging −0.538, and were under the Mojonnier readings in 18 of the 24 trials, or 75 per cent (table 5). The readings ranged from −0.31 to −0.50 per cent under those of the Mojonnier and from +0.03 to +0.16 per cent above, and averaged −0.29 per cent. Nevertheless, the same tests on the nonhomogenized milk consistently were above those of the Mojonnier, averaging +0.255 per cent higher.

a. *The modified Pennsylvania method.* Since the average Pennsylvania tests on the homogenized milk were lower than both the Pennsylvania test

and the Mojonnier test for nonhomogenized milk, attempts were made to improve the test for homogenized milk by increasing the specific gravity of the acid used from 1.73 to 1.81. This modification increased the reading on the nonhomogenized milk slightly, averaging about 0.02 per cent, and that of the homogenized milk about 0.53 per cent, bringing the average readings of the nonhomogenized and homogenized milk within 0.032 per cent of each

TABLE 5

Comparison of Pennsylvania and Mojonnier tests of homogenized milk

Series	Pennsylvania method			Variations from Mojonnier	
	Nonhomogenized	Homogenized	Variation of homogenized from nonhomogenized	Nonhomogenized	Homogenized
	%	%			
1	3.88	3.28	−0.60	+0.23	−0.39
2	3.87	3.20	−0.67	+0.17	−0.50
3	4.05	3.83	−0.22	+0.34	+0.13
4	4.05	3.88	−0.17	+0.33	+0.15
5	4.15	3.85	−0.30	+0.34	+0.03
6	4.03	3.38	−0.65	+0.21	−0.43
7	4.20	3.88	−0.32	+0.34	+0.05
8	4.20	4.00	−0.20	+0.30	+0.11
9	4.17	3.55	−0.62	+0.26	−0.36
10	4.65	3.98	−0.67	+0.26	−0.43
11	4.67	4.10	−0.57	+0.20	−0.40
12	4.80	4.08	−0.72	+0.27	−0.47
13	4.82	4.10	−0.72	+0.24	−0.47
14	4.82	4.20	−0.62	+0.25	−0.39
15	4.82	4.75	−0.07	+0.23	+0.16
16	4.85	4.15	−0.70	+0.26	−0.44
17	4.90	4.30	−0.60	+0.30	−0.34
18	4.80	4.15	−0.65	+0.19	−0.46
19	4.85	4.18	−0.67	+0.23	−0.46
20	5.00	4.30	−0.70	+0.24	−0.46
21	5.00	4.43	−0.57	+0.21	−0.45
22	5.22	4.50	−0.72	+0.26	−0.44
23	5.27	4.65	−0.62	+0.24	−0.39
24	5.32	4.75	−0.57	+0.22	−0.31
Av.	4.599	4.061	−0.538	+0.255*	−0.290*

* Highly significantly different from zero.

other (table 6). The tests on the homogenized milk became consistently higher than those of the Mojonnier, averaging +0.238, whereas the regular Pennsylvania tests were under those of the Mojonnier in 75 per cent of the cases. The wide variation encountered between the tests of nonhomogenized and homogenized milk when made by the Pennsylvania method were narrowed appreciably when sulfuric acid of 1.81 specific gravity was used in the test (table 6 and fig. 1). Nevertheless, the average readings were considerably above those of the Mojonnier (fig. 1).

The data for all tests are summarized in table 7 and figure 1.

TABLE 6

Comparison of modified Pennsylvania and Mojonnier tests on homogenized milk

Series	Modified Pennsylvania method			Variations from Mojonnier	
	Nonhomogenized	Homogenized	Variation of homogenized from nonhomogenized	Nonhomogenized	Homogenized
	%	%			
1	3.90	3.88	−0.02	+0.25	+0.21
2	3.95	3.90	−0.05	+0.25	+0.20
3	4.05	4.00	−0.05	+0.34	+0.30
4	4.08	4.08	0.00	+0.36	+0.35
5	4.15	4.13	−0.02	+0.34	+0.31
6	4.02	4.00	−0.02	+0.20	+0.19
7	4.15	4.15	0.00	+0.29	+0.32
8	4.22	4.20	−0.02	+0.32	+0.31
9	4.20	4.15	−0.05	+0.31	+0.24
10	4.63	4.55	−0.08	+0.24	+0.14
11	4.78	4.68	−0.10	+0.31	+0.18
12	4.77	4.75	−0.02	+0.24	+0.20
13	4.78	4.80	+0.02	+0.20	+0.23
14	4.85	4.87	+0.02	+0.28	+0.28
15	4.87	4.85	−0.02	+0.28	+0.26
16	4.83	4.83	0.00	+0.24	+0.24
17	4.90	4.80	−0.10	+0.30	+0.16
18	4.87	4.82	−0.05	+0.26	+0.21
19	4.90	4.88	−0.02	+0.28	+0.24
20	5.03	4.93	−0.10	+0.27	+0.17
21	5.03	5.03	0.00	+0.24	+0.25
22	5.23	5.20	−0.03	+0.27	+0.26
23	5.30	5.23	−0.07	+0.27	+0.19
24	5.35	5.35	0.00	+0.25	+0.29
Av.	4.618	4.585	−0.032	+0.274*	+0.238*

* Highly significantly different from zero.

TABLE 7

Comparison of various fat tests of nonhomogenized and homogenized milk (Av. 24 trials)

Test	Percentage fat in		Variation of test of homogenized milk from that of nonhomogenized milk	Variation of test of homogenized milk from Mojonnier test
	Nonhomogenized milk	Homogenized milk		
Mojonnier	4.344	4.347	+0.003	.....
Babcock*	4.402	4.390	−0.012	+0.043†
Gerber	4.434	4.437	+0.003	+0.090†
Minnesota	3.886	3.913	+0.027	−0.433†
Pennsylvania	4.599	4.061	−0.538	−0.290†
Pennsylvania‡	4.618	4.585	−0.032	+0.238†

* Acid and milk at 70° F., 17.5 ml. of 1.835 sp. gr. acid added in 3 portions, shaken by hand after each addition and finally shaken in shaking machine for at least 2 minutes.

† Highly significantly different from zero.

‡ Specific gravity of acid adjusted to 1.81 instead of the recommended specific gravity of 1.73.

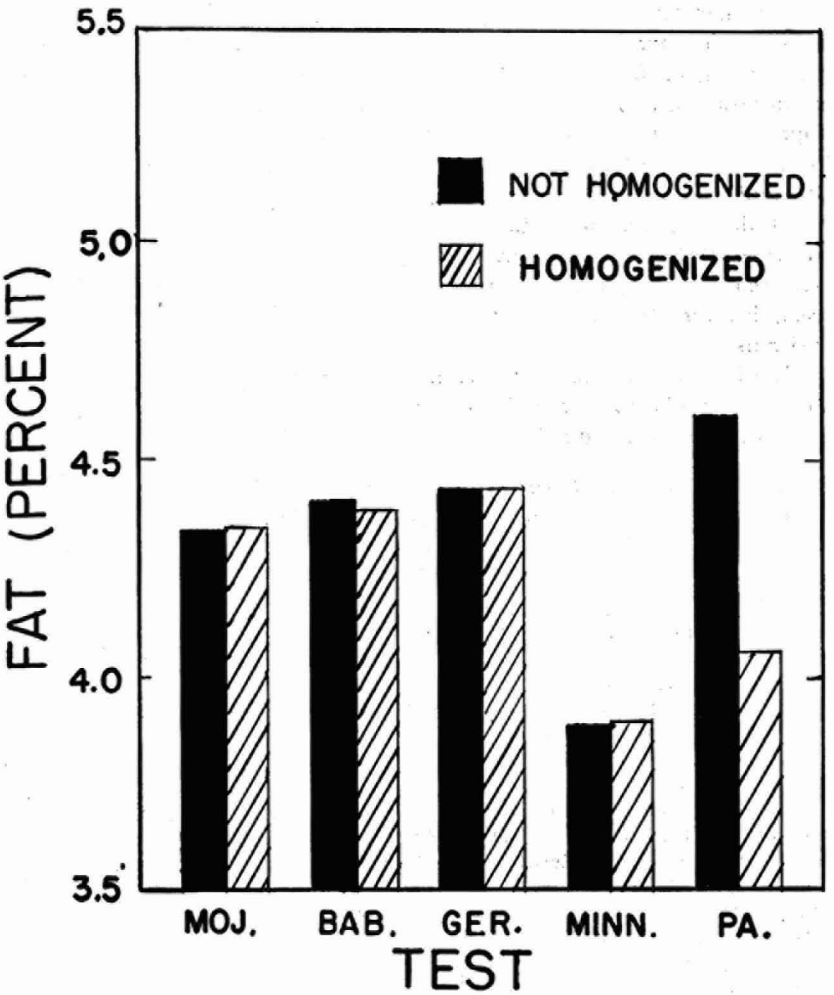

FIG. 1. Fat percentage in milk as determined by the Mojonnier, modified Babcock, Gerber, Minnesota, and Pennsylvania method (average 24 trials).

CONCLUSIONS

Homogenization does not affect the Mojonnier fat test of milk.

The modified Babcock method (17.5 ml. of 1.835 sp. gr. sulfuric acid added in three portions, 8, 5, and 4.5 ml., respectively, and shaken for at least 2 minutes before centrifuging) may be used with much assurance of accuracy in testing homogenized milk. Twenty-four tests in duplicate averaged within − 0.012 per cent of those of nonhomogenized milk made by the same method and within + 0.043 per cent of the Mojonnier average.

Homogenization does not affect the Gerber test. The average Gerber tests, both of nonhomogenized and homogenized milk, were found to be 0.09 per cent higher than those secured by the Mojonnier method. Aside from the necessity of introducing another test and the fact that the readings were approximately 0.1 per cent higher than the Mojonnier, the Gerber test was by all odds the most satisfactory test studied for making fat tests of homogenized milk.

While the Minnesota method yielded average tests of homogenized milk within +0.027 per cent of those of nonhomogenized milk, the tests varied from those of the Mojonnier on the average by −0.433 per cent. It would seem, therefore, that the test could not be recommended for testing homogenized milk.

The Pennsylvania method, yielding tests on homogenized milk in these studies markedly lower than the Mojonnier method, cannot be recommended for testing homogenized milk.

Credit is due Mr. Robert Frantz for the making of the tests and Dr. W. D. Baten for the testing of significance of some of the data reported herein.

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A METHOD FOR MEASURING THE BODY OF CULTURED CREAM

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The body or viscosity of cultured cream has been measured by various investigators. After uniform agitation of the cultured cream, Guthrie (2) used a MacMichael viscosimeter to determine differences in the body of the product. Two methods were employed by Doan and Dahle (1), namely: (*a*) a viscosimeter of the rotating type and (*b*) "a special plunger test where the penetration of a suitable plunger falling a unit distance into the product was measured". No details were given as to the plunger or method of testing. Joffe (3) describes a method of testing the consistency of mayonnaise and salad dressing, two products which have a consistency similar to cultured cream. He used an instrument called a "plumit". This is a graduated rod of aluminum, bearing a pointed and weighted head of larger diameter than the rod. The total weight is 14.5 g. and the over-all length 13 cm. The plumit is held between the thumb and forefinger and dropped into a jar of mayonnaise from a height of 12 inches. When the plumit is released and drops into the sample, it should remain perpendicular, and a reading of the depth of penetration is taken at once.

Body structure or the apparent viscosity of cultured cream, developed without the addition of stabilizing agents, may be reduced readily to a basic viscosity by means of gentle agitation. It seems desirable to evaluate the uniformity of the product as sold to the consumer by measuring the body of the cultured cream while in the final container and without reducing the apparent viscosity. An aluminum rod, drilled, tapered, and graduated, has been constructed for this purpose. The size of the hole ($13/32'' \times 3\ 3/4''$) was selected to provide a desirable ratio of weight to volume displacement. The dimensions and mode of construction of this device, called a plummet, are given in figure 1. A release for the plummet (made from a glass tube and a board), a stop watch with a second hand, and a ring stand and clamp also are needed.

The procedure for conducting the test is as follows:

(a) Hold samples to be tested overnight at 40° F. If the retail container is less than 4 inches high and the exposed surface less than 2 inches in diameter, suitable containers (such as an 8-oz. mayonnaise jar) should be employed and filled and handled in a manner identical to the commercial product. Avoid agitating the product prior to testing.

(b) Firmly secure the glass tube in a vertical position with a suitable

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clamp, having the end of the tube exactly 12 inches above the center surface of the cultured cream.

(c) Insert the plummet, point downward, in the glass tube and hold in

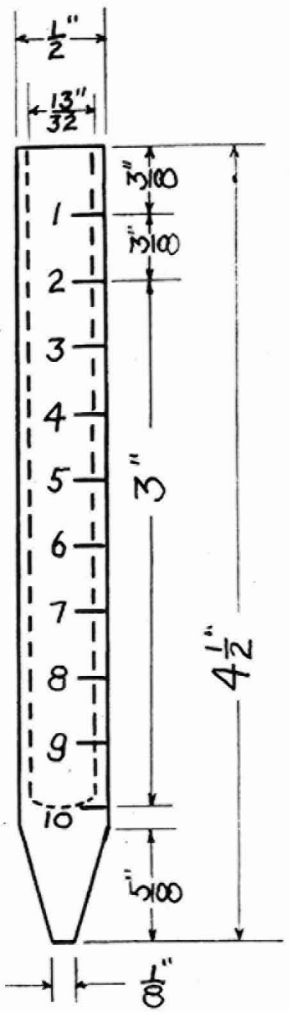

FIG. 1. Construction of plummet.

place with the smooth surface of the small board, maintaining a horizontal position against the bottom of the tube.

(d) Release the plummet by sliding the board quickly to one side.

(e) Lift the plummet from the cultured cream 5 seconds after its release.

(f) The cream will adhere to the plummet to a distance depending on the depth of penetration. Observe the cream line reading to the nearest quarter division of the scale. The cream line mark may not correspond to the true depth of penetration, due to the meniscus.

(g) An average of three tests is used as the measure of the body of the product. Use a different container of product for each test.

(h) The plummet should be washed and dried after each test.

TABLE 1

The body of cultured cream as measured by the plummet method

Plant no.	Batch no.	Plummet reading				Maximum deviation between individual sample containers
		Container no.			Av.	
		1	2	3		
1	1	7.50	7.25	7.25	7.33	0.25
	2	7.75	7.75	7.75	7.75	0.00
	3	7.25	7.50	7.50	7.42	0.25
	4	8.00	8.25	8.25	8.17	0.25
	5	7.75	8.25	8.00	8.00	0.50
	6	7.50	7.50	7.50	7.50	0.00
2	1	5.75	6.00	6.00	5.92	0.25
	2	7.00	7.25	7.00	7.08	0.25
	3	6.25	6.75	6.00	6.33	0.50
	4	7.00	7.25	6.50	6.91	0.75
	5	7.50	7.00	6.50	7.00	1.00
	6	7.25	6.75	7.00	7.00	0.50
3	1	5.00	5.50	5.25	5.25	0.50
	2	5.50	5.25	5.75	5.50	0.50
	3	6.75	7.25	6.50	6.83	0.75
	4	4.50	4.25	3.75	4.16	0.75
	5	4.75	4.25	4.50	4.50	0.50
	6	5.00	4.50	4.75	4.75	0.50
4	1	6.50	6.50	7.00	6.66	0.50
	2	8.00	8.50	8.00	8.16	0.50
	3	5.50	6.25	5.75	5.83	0.75
	4	7.75	8.00	.....	7.87	0.25
	5	< 0	< 0	< 0	.....	.....
	6	7.00	7.50	7.00	7.16	0.50
5	1	4.50	4.25	4.00	4.25	0.50
	2	6.00	5.75	6.50	6.08	0.75
	3	5.75	5.50	5.75	5.66	0.25
	4	5.00	4.50	4.50	4.66	0.50
	5	6.00	5.50	5.50	5.66	0.50
	6	6.00	6.00	5.50	5.83	0.50
6	1	3.25	3.50	3.25	3.41	0.25
	2	3.75	3.50	3.50	3.56	0.25
	3	4.00	4.25	3.75	4.00	0.50
	4	3.50	3.50	3.75	3.56	0.25
	5	3.50	3.50	3.50	3.50	0.00
	6	3.25	3.50	3.50	3.41	0.25

Data presented in table 1 give the body of cultured cream as produced by six dairy plants located in eastern United States. Examination of these data indicates that the variations existing between measurements of indi-

vidual containers of the same lot of cultured cream are within the practical limits of controlled testing. A variation of ± 0.5 division is considered a suitable tolerance range. Daily tests on the body of cultured cream may be observed to indicate any variations from a predetermined standard.

The consensus of three experienced judges in correlating the visual viscosity of cultured cream with the plummet reading may be found in table 2.

TABLE 2

Relation of plummet readings to visual viscosity of cultured cream

Plummet reading	Visual viscosity
0 – 2	Very thin
2 – 4	Thin
4 – 6	Medium
6 – 7.5	Good
7.5– 8.5	Slightly heavy
8.5–10	Heavy
Over 10	Very heavy

SUMMARY

A simple method has been developed for measuring the body of cultured cream. The resistance of this product to the penetration of a plummet is taken as an indication of the body.

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THE FLAVOR, VOLATILE ACIDITY, AND SOLUBLE PROTEIN OF CHEDDAR AND OTHER CHEESE[1]

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The method of manufacturing Cheddar cheese has been known for many generations. About 50 years ago scientists began an intensive study of the factors affecting the flavor of this cheese with the idea that the source and identity of the flavoring substances could be established. Although much scientific knowledge has been accumulated from these studies, the specific flavoring materials are still unknown. The present trend toward the manufacture of Cheddar cheese from pasteurized milk has accentuated the need for this knowledge, as pasteurized milk cheese has less flavor and slightly different characteristics than that found in raw milk cheese.

The literature is voluminous and only a few references will be cited. The fundamental chemical changes that occur during the ripening process as known in 1891 were stated by Van Slyke (17). He wrote that there was a slow evolution of carbon dioxide from the casein or fat, or both. Volatile and nonvolatile fatty acids developed from the fat. The nitrogen compounds, especially casein, broke down into soluble compounds, some eventually becoming ammonia. Cured cheese was more alkaline than fresh cheese. The formation of the free fatty acids was the principal chemical change during ripening.

Van Slyke, Harding, and Hart (18) concluded from their study of rennet that this enzyme did not decompose protein into compounds that produced flavor in cheese. Suzuki, Hastings, and Hart (16) studied the origin and composition of steam distillate from cheese which contained the flavor compounds. They found bacteria to be the principal ripening agent. The lactose disappeared from cheese in 3 to 6 days but some of the lactates were fermented into volatile fatty acids, especially acetic and propionic. Butyric and caproic acids were derived from the fats and proteins. Succinic acid, alcohols, and esters also were present in the steam distillate.

Improved Cheddar cheese flavor has been reported with special cultures in Cheddar cheese making in addition to the usual lactic starter. Hucker and Marquardt (7) found that a *Streptococcus paracitrovorus* culture used with Hansen's commercial starter produced characteristic cheese flavor of superior quality from pasteurized milk. Proteolytic coccus cultures produced bitter flavor, as did the culture of *S. paracitrovorus* when used without starter. Hansen, Bendixen, and Theophilus (3) confirmed that cheese

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made with *S. paracitrovorus* alone became bitter, and they obtained similar results with *Streptococcus citrovorus*. However, the quality of cheese made from raw or pasteurized milk with lactic starters was not improved by the addition of *S. paracitrovorus* or *S. citrovorus*. Definite improvement in the quantity and quality of Cheddar cheese flavor was obtained by Lane and Hammer (8) when cultures of selected strains of *Lactobacillus casei* were used in pasteurized milk to which commercial lactic starter had been added. The protein decomposition was greater and the flavor improved due to this bacterium. More recently, Sherwood (13, 14) isolated 720 strains of lactic acid bacteria from pasteurized milk Cheddar cheese in New Zealand. The dominant organism was *Lactobacillus* (*Streptobacterium*) *plantarum*, with *Lactobacillus* (*Streptobacterium*) *casei* occurring less frequently. Betabacteria and betacocci were found in small numbers. Some strains of these bacteria produced good Cheddar cheese flavors. Studies in the laboratory and in factories verified Lane and Hammer's good results (8) with a special strain of *L. casei*, but best cheese flavor was obtained by the addition of 10 ml. of culture of *L. plantarum* to 80 gallons of milk to give an inoculation of about 12,000 organisms per ml. of pasteurized milk.

The rôle of the hydrolysis of milk fat and the development of volatile acids in relation to flavor has been emphasized by the studies of Lane and Hammer (9, 10, 11). The homogenization of milk for the manufacture of blue cheese improved the texture and increased volatile acidity and flavor. In Cheddar cheese the volatile acidity and flavor were greater for raw milk cheese than for pasteurized milk cheese. Homogenization of the milk or the addition of lipase from several sources generally produced rancid, bitter cheese, but these flavors tended to disappear with age. Desiccated mammary tissue added to cheese milk often produced desirable Cheddar flavor. Babel and Hammer (1) found that the lipase in mulberry juice or rennet extract often did improve the flavor of Cheddar cheese, but too much of the enzyme produced bitter flavor. Dahle and Watrous (2) based their new procedure for making Parmesan-type cheese on the fact that homogenization of the milk promoted the development of the rancid flavor and aroma desired in this grating cheese for flavoring spaghetti and soups.

Cheese ripening generally is followed by increased volatile fatty acids and increased soluble nitrogen. Both chemical changes are used to indicate the degree of ripening as associated with the development of flavor, and increased soluble nitrogen with the development of a mellow, waxy body. The usual steam distillation of cheese for volatile acids does not give correct results, according to Hiscox, Harrison, and Wolf (4, 5, 6) who developed a long, accurate method for estimating these acids. The accurate, rapid technic of Smiley, Kosikowsky, and Dahlberg (15) has made it possible easily to analyze commercial cheese for total volatile acidity and to compare such values with flavor scores and intensities.

This study was undertaken to show the relationship of total volatile acidity to flavor, and consideration also was given to several other chemical determinations, including soluble nitrogen.

METHODS

Five cheese manufacturers or processors in New York and Wisconsin were requested to select three Cheddar cheeses that represented mild, medium, and sharp flavors of excellent quality. Each sample was to be selected as being a typical good Cheddar cheese. The cheese selectors were cautioned to avoid choosing the cheese on the basis of age and to depend solely upon examination of the cheese. In one case the three cheeses received from one manufacturer were made at one plant.

As the 15 samples were received, they were classified as mild, medium, or sharp in flavor. After all had been received, they were arranged in order of the intensity of the Cheddar flavor by the authors working independently and then together. The samples were analyzed for volatile acidity, soluble protein, pH, moisture, and salt.

Samples of cheese of several varieties other than Cheddar were purchased at a retail grocery store. These samples were classified as to flavor intensity and analyzed chemically. They were rated on the basis of intensity of flavor within their respective varieties and also without regard to variety.

Finally, a manufacturer of Camembert cheese was asked to select several samples that were approximately the same age and had been treated similarly but which showed differences in the degree of ripeness and intensity of flavor. The four samples were scored and classified by the manufacturer and his comments were confirmed by the authors.

The total volatile acidity was determined by the method of Smiley, Kosikowsky, and Dahlberg (15), and the pH by the Beckman pH meter, using glass electrodes.

The solution of the soluble protein followed a technic based upon the method of Sharp (12). The principle of the method is to maintain the pH (approximately 5) and the salt content comparable to that of Cheddar cheese by a buffer salt solution while the soluble protein is being dissolved in the water. The soluble protein was extracted as follows: Three grams of cheese are weighed within 0.01 g. error and placed in a porcelain mortar. A small amount of extracting solution at 50° C. is added and the cheese is ground to a thick paste. Additional solution is added to dilute the paste. The dilute suspension of cheese is transferred to a 100-ml. flask. The mortar is rinsed with additional portions of the solution. The flask is placed in a water bath at 50° C., filled to the mark with extracting solution, and, with occasional shaking, maintained at this temperature for one hour. The solution is filtered through a fluted filter, and 50 ml. of the filtrate is placed in a Kjeldahl flask.

The soluble protein extraction solution is prepared as follows:

A. Stock solution

57.5 ml. glacial acetic acid
136.1 g. sodium acetate (3 H_2O)
47.0 g. sodium chloride
8.9 g. calcium chloride (anhydrous)

Add water to make 1 liter.

B. Extraction solution

Make 250 ml. stock solution up to 1 liter with water.

RESULTS

Selected Cheddar Cheese

The data on Cheddar cheese, presented in table 1, do not show any striking relationships of intensity of cheese flavor with any of the factors studied. In a general way it may be stated that the comments of the manufacturers of the cheese agreed well with those of the authors as to the intensity of the cheese flavor. The scores of the cheese showed that all samples were good Cheddar cheese but the scores were not related to intensity of flavor.

It was true that the two oldest samples of cheese (E1 and A2 which were 13 and 14 months of age) were the highest in flavor intensity. However, age of cheese cannot be segregated from temperature of storage, for curing cheese is a time-temperature problem and this temperature was not reported. This probably explains the reason that the cheese (B3 and B4) which rated third and fourth in strength of flavor were among the youngest, 2 and 3 months old, for the buyer of this cheese often force-cures it at about 60° F., as compared with the usual storage temperature of 32 to 35° F. For this reason and others, flavor intensity and age of cheese were not associated closely enough to be able to state that a given cheese was strong in flavor because it was old (10 to 12 months) or that another was mild in flavor because it was young (2 to 4 months).

The principal object of this study was to establish the relationship between the intensity of Cheddar cheese flavor and total volatile acidity. There were two samples with volatile acidities below 20 ml. N/10 acid per 100 g. of cheese. These samples were 13 and 7 months old and were first and fourteenth in flavor intensity. There were three samples with volatile acidities over 40. These samples were 14, 2, and 2 months old and were second, seventh, and eleventh in intensity of flavor. With the two cheeses of lowest volatile acidity representing the most and next to the least flavor intensity, and the cheeses of highest volatile acidity also scattered as to flavor intensity, it is evident that a sample of Cheddar cheese could not be classed as to flavor intensity on the basis of total volatile acidity. There appears

TABLE 1

The relationship of flavor intensity, volatile acidity, soluble protein, and other constants in commercial Cheddar cheese of good flavor

Sample no.*	Age of cheese	Raw or past. milk	Comment on flavor		Authors' score	Order of flavor intensity	Volatile acidity†	Soluble protein	pH	Moisture	Salt
			Mfgr's.	Authors'							
	(*mos.*)							(%)		(%)	(%)
E1	13	Raw	Sharp	Sharp	94	1	16.8	8.40	5.10	35.56	1.33
A2	14	Past.	Sharp	Sharp	92	2	48.0	8.88	5.20	35.91	1.41
B3	3	Raw	Sharp	Sharp −	92	3	29.2	5.56	5.00	39.01	1.87
B4	2	Raw	Medium	Sharp −	91	4	32.6	5.53	5.06	37.73	1.45
C5	12	Raw	Medium	Medium +	90.5	5	18.8	8.17	5.33	33.60	2.00
D6	12	Past.	Sharp	Mild +	93	6	24.0	7.27	5.51	35.95	2.13
B7	2	Raw	Medium	Medium +	90	7	40.5	4.92	5.18	37.49	1.39
C8	9	Raw	Sharp	Medium	91.5	8	25.8	7.47	5.10	35.68	1.98
B9	3	Raw	Mild	Medium	91	9	23.2	7.12	5.30	39.99	1.58
D10	9	Past.	Medium	Medium −	92	10	24.0	5.81	5.28	37.25	1.48
A11	2	Raw	Mild	Mild +	92	11	40.8	4.82	5.00	34.26	1.23
A12	10	Past.	Medium	Mild +	91.5	12	28.3	7.15	5.08	33.97	1.03
D13	4	Past.	Mild	Mild +	92	13	25.0	4.53	5.39	37.79	2.05
E14	7	Past.	Mild	Mild	92	14	13.7	6.68	5.25	37.53	1.48
C15	3	Raw	Mild	Mild	92	15	21.7	5.56	5.49	35.64	1.48

* The letter refers to the cheese manufacturer or processor who selected the samples.
† Ml. N/10 acid per 100 g. cheese.

to be almost no general trend in the relationship between volatile acidity and flavor intensity.

The data on the relationship between soluble protein and flavor intensity did not happen to be so strikingly negative as was the case for total volatile acidity. Samples E1 and A2, with the greatest amount of soluble protein, 8.40 and 8.88 per cent, respectively, were oldest and ranked first and second in intensity of Cheddar cheese flavor. However, the relationship between the two factors appeared to end with these two samples. Samples with less than 5 per cent soluble protein were seventh, eleventh, and thirteenth in

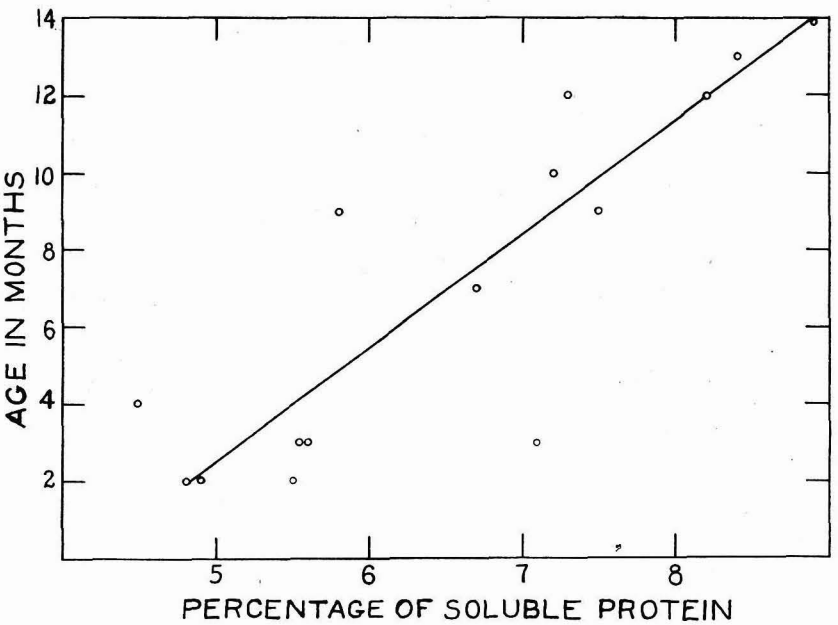

FIG. 1. Relation of percentage of soluble protein to age of Cheddar cheese.

flavor. Samples with 5 to 6 per cent soluble protein were third, fourth, tenth, and fifteenth in flavor intensity. There was no obvious trend in the relationship between these two factors.

The percentage of soluble protein increased with increased age of the cheese (fig. 1). This trend had some exceptions but it was reasonably good considering the varied character of the cheese. A similar relationship did not exist between total volatile acidity and age of the cheese.

There is nothing in the data to suggest any correlation of flavor intensity with the pH, moisture, and salt content of the cheese.

Miscellaneous Cheese Varieties

The miscellaneous varieties of cheese purchased at a grocery store gave

TABLE 2

The relationship of volatile acidity, pH, and the quality and intensity of flavor of various types of cheese

Cheese variety	Cheese characteristics			Volatile acidity*	pH
	Relative intensity of flavor of all cheese	Flavor in each individual cheese class			
		Intensity of flavor	Quality remarks		
Camembert	1	Strong	Overripe	39.9	7.43
Blue	2	Medium	Good	40.4	6.00
Kaukauna Klub Cheese Food	3	Medium	Good	30.8	5.36
Liederkranz	4	Strong	Good	102.8	7.27
D'Oka (Trappist)	5	Strong	Fair	49.2	5.90
Chantelle	6	Medium	Fair	31.4	5.23
Swiss	7	Mild	Good	49.5	5.57

* Ml. N/10 acid per 100 g. cheese.

very interesting data (table 2). A high-flavored, overripe, soft Camembert cheese with an ammonia odor was rated as having the strongest flavor. It was alkaline in pH. A green, mild but good-flavored Swiss cheese was rated lowest in flavor; yet the total volatile acidity of the Swiss was greater than that of the Camembert. A blue cheese of medium-strength flavor of good quality was rated second in flavor intensity and its volatile acidity was the same as that of the Camembert. A strong-flavored Liederkranz cheese that was slightly alkaline contained more than twice as much volatile acidity as any other cheese; yet it was not the strongest-flavored cheese. Its flavor was very much the same as the D'Oka cheese with only half the volatile acidity.

It is appreciated that this attempt to rate cheese of different varieties on intensity of flavor is subject to criticism. The flavors are so different that intensities cannot be compared closely. After making allowances for such discrepancies, there can be no doubt concerning the lack of relationship between total volatile acidity and intensity of flavor.

TABLE 3

Analysis of four domestic Camembert cheeses from different lots made in the same plant

Cheese	Age	Manufacturer's grade		Volatile acidity*	Soluble protein	pH	Moisture
		Score	Comments				
	(*days*)				(%)		(%)
1	48	20.0	Mild flavor Slight flat Poor breakdown	20.4	5.84	6.63	52.03
2	45	21.0	Mild flavor Fair breakdown	16.1	6.00	6.78	53.56
3	48	21.5	Fair flavor Fair breakdown	18.6	6.53	7.01	51.00
4	47	22.0	Good cheese	21.4	6.41	6.95	51.93

* Ml. N/10 acid per 100 g. cheese.

Selected Camembert Cheese

The ripening of Camembert cheese is sometimes subject to unexpected flavor variations which might be associated with total volatile acidity and soluble protein. It is recognized that the softening of the cheese is dependent upon protein solubility. A manufacturer of Camembert selected four cheeses of approximately the same age but with marked variation in the amount of good Camembert flavor (table 3). The manufacturer's score and comments on the cheese were used for comparisons with analysis.

The total volatile acidities of the cheese with the least flavor and with the most flavor were practically identical. The percentage of soluble protein and the pH value increased as the flavor increased in intensity and the cheese became softer in body. It is possbile that the relationship between intensity of flavor and changes in soluble nitrogen and pH were incidental to the obvious change in the body of the cheese, which must be related to these changes.

DISCUSSION

The tendency toward the manufacture of cheese from pasteurized milk has emphasized the lack of knowledge of those chemical entities which are responsible for the characteristic flavor of cheese. The literature of the last century gave the two major chemical changes that occur during ripening, namely, the increase in total volatile and nonvolatile acidity, and the increase in soluble protein. The emphasis was given to volatile acidity more than to the decomposition products of protein. Many investigators have endeavored to increase cheese flavor by the bacteria and enzymes which affect the fat and the casein.

This research has established that the magnitude of these chemical changes is not related to the intensity of the flavor of Cheddar cheese. The increase in total volatile acidity and soluble nitrogen during ripening is interesting and valuable information to obtain on cheese ripening, but flavor development is not related to these characteristics. This means that much of the research on the development of cheese flavor has been based upon a fundamental misconception. It may be that the cheese flavor is a result of the decomposition of milk fat or protein, but, if such is the case, the flavor compounds are developed without regard to the total changes in these two materials. In other words, if the flavor compounds of Cheddar cheese are volatile fatty acids, then the quantity of the flavor-producing acids is not related to total volatile acidity. It has been assumed fallaciously that these two were synonymous, as the volatile acids contain most of the cheese flavor.

Cheese flavoring compounds are developed during ripening incidental to the common chemical changes with which investigators often are concerned. This means there is need for a widening of the concept behind the studies of cheese flavor. More rapid progress may be made by new manu-

facturing technics or by identification of the flavor compounds. There is real hope for producing higher flavors in pasteurized milk cheese. For example, sample A2 was a pasteurized milk Cheddar cheese that possessed second highest flavor and the highest volatile acidity and soluble protein. This cheese may have been an exception for the plant that made it, but the fact is that it was produced.

As cheese ripens there is an increase in flavor, volatile acidity, and soluble protein. The lack of any correlation among these progressive changes in Cheddar cheese, except for a general relationship between age and soluble protein, does not disprove their occurrence. Instead, it emphasizes that there are a number of factors which affect each of these changes in varying degrees and partially obscure the effect of age alone. The direct relationship between age and soluble protein might be explained as being due chiefly to the action of rennet as affected by time, with other factors being less important in their total effects. The effect of microorganisms on the development of flavor is of major importance and is influenced greatly by a number of factors other than variations in time.

CONCLUSIONS

Cheese manufacturers and processors in New York and Wisconsin selected 15 Cheddar cheeses with typical good flavors that were mild, medium, and sharp in intensity. The cheese varied from 2 to 14 months of age. There were no relationships among intensity of flavor, total volatile acidity, soluble protein content, pH, and age of the cheese, except for a direct relationship between age and soluble protein. The flavor compounds were distilled with the volatile acids but apparently were not directly correlated as to total amounts.

No relationship was found between intensity of flavor and total volatile acidity in seven different varieties of cheese secured at a retail store.

Four samples of Camembert cheese made in one factory were selected to show difference in flavor and texture. There was no relationship between intensity of flavor and total volatile acidity but there was a direct relationship between flavor intensity of this cheese and its soluble protein and pH values.

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THE VALUE OF SUPPLEMENTARY VITAMIN FEEDING IN THE REARING OF DAIRY CALVES

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Widespread interest in the vitamin needs of dairy calves was aroused through several reports (5, 6, 9, 10) that supplementary vitamin feeding during the first few weeks of life prevented so-called "nutritional scours", lessened navel infection, and reduced the death rate. The studies pointed to vitamins A and C and nicotinic acid as essential components of the ration of the young calf. The reported beneficial effects of vitamin supplementation were so striking that it was considered desirable to test the value of such a procedure in a dairy herd in which good feeding practices are followed throughout the year. On the basis of a number of published studies showing a relation between the character of the ration and the vitamin content of colostrum milk, it was assumed that the mother's ration during the gestation period also may affect the store of vitamins in the body of the calf at birth. Recent reports (3, 11, 14) tend to substantiate the validity of such an assumption.

A further assumption based on numerous calf-raising trials is that the most critical period in the life of the hand-fed dairy calf is within the first 30 days after birth. An early investigation in the feeding of dairy calves conducted at this Station (1) indicated that the character of the ration during the first 3 weeks is of prime importance. The data reported in this paper, therefore, cover only records up to 30 days of age. Histories of 299 calves, approximately one half of them males, are summarized.

PROCEDURE

The study was carried out with calves born in the Station dairy herd. The cows in this herd were fed hay, silage, and grain mixture throughout the year, with limited access to pasture during the growing season. The quality of all feeds, as a rule, was much above average. Alfalfa hay was the chief dry roughage, with smaller amounts of red clover hay and Korean lespedeza hay. The calves usually were left with their mothers for 2 days after birth, but some weak calves were left as long as 4 days. After separation from their dams they were kept in special quarters at two different locations. Feeding of whole milk (Holstein) was continued throughout the 30-day period of observation covered by these records. The calves were given free access to adequate amounts of red clover hay and a grain mixture. Liveweights were taken as early as possible after birth. However, some calves were born when no attendant was present, and probably a part of these had opportunity to nurse before they were weighed. These weights, therefore,

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are termed first-day weights, rather than birth weights. Liveweights also were taken at 15 days and at 30 days of age.

The vitamin supplements were supplied in two forms. Nopco special A and D feeding oil with a potency of 2,000 units of A and 800 units of D per gram was supplied at the rate of approximately 2 ml. per head daily to all calves at one barn for the first half of the experimental period and none was given during the second half of the period. At the other barn the practice was reversed. Approximately equal numbers of calves were included in the groups fed oil and no oil. The other form of supplement consisted of vitamin capsules, the formulae for which were as follows:

	Black capsule	*White capsule*
Vitamin A, U.S.P. units	5,000	5,000
Vitamin D (Irradiated ergosterol), U.S.P. units	500	500
Nicotinic acid, mg.	50	50
Vitamin C (Ascorbic acid), mg.	250	.....

Random selection of the calves to be fed the vitamin capsules was achieved by following the rule that the first calf born was to be fed vitamin capsules, the next one to be given no vitamin capsules, and so on. Thus one half of the calves were fed vitamin capsules and the remainder served as controls. One capsule containing vitamins A and D, nicotinic acid, and ascorbic acid was given daily per calf from 1 to 10 days of age and one capsule containing only vitamins A, D, and nicotinic acid was administered daily from 11 to 30 days of age.

Four experimental groups were established. Group I received no vitamin supplement, group II received the vitamin capsules, group III received the vitamin A and D oil supplement and group IV received both the vitamin capsules and the oil supplement.

An individual record sheet for each calf was posted on a bulletin board and records kept of the vitamins and milk fed, liveweights, condition of the calf, and, in the event that scours occurred, the treatment given and the duration of the ailment. The trials reported in this paper began early in 1944 and extended through September, 1946.

RESULTS

A summary of the records of all calves which survived the 30-day observation period is given in table 1. Characteristic breed differences were noted in the first-day weights of the calves. The average weights were: Ayrshires, 76 lbs.; Brown Swiss, 98 lbs.; Guernseys, 66 lbs.; Holsteins, 96 lbs.; and Jerseys, 50 lbs. The average gains in liveweight were somewhat greater for the Brown Swiss and Holsteins than for the other breeds. All of the average gains, however, were satisfactory for the breeds represented with the exception of those for the Guernseys in group II. This group included three calves which made very small gains. The average 30-day

TABLE 1

Effects of vitamin supplementation on liveweight gains and incidence of scours in dairy calves

Breed*	No. of calves	Av. values per head			Milk fed	Scours		
		First-day weight	Gain in weight			Number of cases	Av. age began	Av. duration
			To 15 days	To 30 days				
		(*lbs.*)	(*lbs.*)	(*lbs.*)	(*lbs.*)		(*days*)	(*days*)
I. Calves fed no vitamin supplement								
A	9	79.1	7.0	18.1	258	3	9	2
B.S.	5	104.9	9.4	20.3	233			
G	7	62.5	7.9	19.9	202	1	12	2
H	35	95.6	9.3	21.0	234	8	7	4
J	12	45.3	8.5	17.7	173	4	9	2
All	68	81.8	8.7 ± 0.32	19.9 ± 0.41	223	16	8	3
Coefficient of variability	.....	.....	43.9 ± 0.36	24.8 ± 0.21	.....	.....	.....	.....
II. Calves fed vitamin capsules								
A	12	75.4	6.9	18.7	238	6	12	5
B.S.	10	97.8	10.1	21.0	214	2	6	3
G	14	62.6	4.5	12.9	183	3	9	3
H	32	97.7	8.6	20.8	234	7	8	3
J	8	49.3	8.2	18.1	184	1	9	3
All	76	82.6	7.7 ± 0.42	18.8 ± 0.97	217	19	9	4
Coefficient of variability	.....	.....	70.0 ± 0.54	45.0 ± 0.35	.....	.....	.....	.....
III. Calves fed vitamin A and D oil concentrate								
A	7	75.7	9.9	23.6	244	1	19	3
B.S.	8	94.2	12.9	26.4	221	2	8	2
G	6	70.3	8.5	18.3	218	1	14	3
H	36	98.1	10.8	25.1	260	10	10	2
J	9	51.8	9.6	20.9	187	6	6	2
All	66	86.4	10.6 ± 0.35	23.9 ± 0.55	239	20	9	2
Coefficient of variability	.....	.....	39.6 ± 0.33	27.3 ± 0.23	.....	.....	.....	.....
IV. Calves fed vitamin capsules plus vitamin A and D oil concentrate								
A	4	69.8	10.7	23.3	242	1	21	2
B.S.	8	97.4	11.1	25.6	245			
G	7	71.9	7.8	21.6	216	1	19	1
H	36	91.7	10.1	26.2	261	7	6	3
J	9	53.3	9.3	19.7	198	2	4	2
All	64	83.5	9.8 ± 0.36	24.5 ± 0.57	243	11	8	2
Coefficient of variability	.....	.....	42.8 ± 0.37	27.2 ± 0.24	.....	.....	.....	.....

* A, Ayrshire; B.S., Brown Swiss; G, Guernsey; H, Holstein; J, Jersey.

gain for the 11 other Guernseys in this group was 16 lbs., a satisfactory figure. The gains for the calves in groups III and IV were larger than those for groups I and II, but the amounts of milk fed to groups III and IV also were larger.

The four groups of calves were similar with respect to the number of cases of scours, age at which the attacks of scours occurred, and the duration of the ailment.

A summary of the records of calves which survived the 2-day nursing period and were started on hand feeding but which failed to complete the 30-day experimental period is given in table 2. Records of calves born dead

TABLE 2

History and apparent cause of death of calves which failed to survive the 30-day observation period

	Group and kind of vitamin supplementation			
	I None	II Vitamin capsules	III A and D feeding oil	IV Capsules and A and D feeding oil
No. of calves	8	6	6	5
Average age at death, days	16	9	14	12
Death attributed to:				
Accidents	.....	1	.....	.....
Indigestion and scours	1	1*	1	1
Pneumonia	1	.....	2	2
Scours and pneumonia	3	1	.....	.....
Too weak to stand or nurse	1	1	1	2
Very weak at birth	2	2	1†	.....
Weak at birth; died from bloat	.....	.....	1	.....

* Mother had mastitis.
† Mother had preparturient mastitis.

and of those that died within 48 hours are not included. Death was attributed to a number of causes, among which pneumonia alone and also scours accompanied by or followed by pneumonia were important. There was little difference between the groups, however, in the number of calves affected. Only two of the calves in group I died at less than 12 days of age. One calf in group I and one calf in group IV died of pneumonia on the 30th day. It was noted that in a considerable number of cases scours did not occur until the calves had reached an age of 2 to 3 weeks.

DISCUSSION

Considerable variability in liveweight gains occurred among the calves of the four groups. The gains to 15 days of age showed greater variability than the gains to 30 days. This was an expected difference because more cases of scours occurred prior to 15 days of age than between 15 and 30 days and, also, some calves which were weak at birth and made a slow start made

good gains after 15 days. The variability of the gains to 30 days of age was, surprisingly, somewhat less than that found at this Station for pasture-fed yearling dairy heifers (7).

The use of vitamin supplements was not effective in reducing the number of cases of scours, the duration of the ailment, and the mortality rate below those of the controls (group I). It appeared that weakness at birth and inability to stand or nurse, the presence of infectious mastitis in the udder of the mother, accidents, and exposure to cold followed by pneumonia were important contributing causes of illness and death.

The use of capsules containing vitamins A and D, together with nicotinic acid and ascorbic acid, was no more effectual in promoting gains in weight or in reducing scours than the use of the special feeding oil containing only vitamins A and D, as judged by the records of calves included in groups II, III, and IV. It is concluded, therefore, that the supplementation of the whole milk ration with ascorbic acid and nicotinic acid was ineffectual in promoting the well-being of the calves in this herd. This finding is in agreement with recent investigations at this Station (4, 12) which showed that ascorbic acid and nicotinic acid are not required by the dairy calf. On the other hand, the same technics used in these investigations disclosed the fact that riboflavin is required by dairy calves (13). These several experiments lend no support to the inference given in a recent report (2) that the supplementary effect of nicotinic acid is dependent upon the level of vitamin A intake.

Our investigations lead us to the conviction that a measure of the progress of the calf during the first 30 days after birth is a better index of nutritional status in early life than is any other period. The character of the ration after 30 days of age may be much more varied than prior to that time. The consumption of high-quality hay and special grain mixture, both of which may be good sources of vitamins and other nutrients, tends to correct nutritional deficiencies incurred during the first few weeks of life. In a recent report of controlled experiments with young calves (8), it is shown that 35 of 57 calves developed cases of scours, but only one of the cases that occurred after 4 weeks of age affected a calf not previously afflicted with the ailment.

Our results do not preclude the possibility that nutritional deficiencies may have been responsible for the onset of scours and other ailments in the case of some calves, particularly those which were too weak at birth to nurse and those which were not strong enough to obtain adequate amounts of colostrum milk. Further, the desirability of vitamin A and D supplementation in the rations of calves born in herds where the rations are low in vitamin value is not disproved. It is assumed on the basis of recent reports (3, 11, 14) that one of the important reasons that vitamin supplementation was of questionable value in our trials was that the cows in the herd were

at all times well fed and that such feeding provided vitamin reserves in the new-born calf.

SUMMARY

Individual records were kept of 299 calves of the Station dairy herd. These were divided at random into four groups to determine the value of vitamin supplementation of the ration during the first 30 days, the critical period in the life of the calf.

The vitamin supplements were of two kinds. One consisted of vitamin capsules containing vitamins A and D, together with ascorbic acid and nicotinic acid. Ascorbic acid was omitted after 10 days of age. The other was a special feeding oil containing vitamins A and D.

The criteria used in evaluating the results were gains in liveweight to 15 days and to 30 days of age, number of cases of scours, age at which scours occurred, duration of scours, number of deaths, and cause of death in those which failed to survive the 30-day period of observation.

The use of vitamin capsules containing ascorbic acid and nicotinic acid in addition to vitamins A and D was not found superior to supplementation with only vitamins A and D, and vitamin supplementation on the whole was of doubtful value, as shown by the bases of measurement used.

ACKNOWLEDGMENT

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THE EFFECT OF CONTINUOUS INTRAVENOUS FEEDING OF VARIOUS SUBSTANCES UPON THE SECRETION OF MILK FAT[1, 2]

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Kaufmann and Shaw (7) showed that carbohydrate when fed as the sole diet provides the precursors of the lower fatty acids of milk fat. As marked hypoglycemia does not in itself produce a decrease in the lower fatty acids (16), it was suggested that dietary carbohydrate acts indirectly either by exerting a sparing action on the utilization of the precursor substances by other body tissues or by being converted into the necessary precursors in the rumen by the action of microorganisms.

It appeared that the best test of the alternative hypotheses would be that of the intravenous and abomasal feeding of glucose to fasted cows and goats. Accordingly, methods were devised for the continuous intravenous and abomasal feeding of ruminants. Using these methods, a study was made of the effect of the administration of glucose and other substances upon the secretion of the lower fatty acids of milk fat.

METHODS

The approach to the problem of ascertaining the blood precursors of the lower fatty acids was similar to that employed in earlier studies (7) in which advantage was taken of the well-known fact that inanition decreases the lower fatty acid content of milk fat. As a marked decrease in the lower acids always occurs within a period of 24 hours of fasting, it was assumed that if the proper precursor or precursors were fed either intravenously or abomasally to a fasted lactating ruminant, the usual decrease in these lower acids would be retarded or prevented. Several substances were administered in this fashion and the effect upon the lower fatty acids of milk fat noted, as shown by the Reichert-Meissl value and, in some cases, the Polenske value. Iodine numbers also were obtained on the milk fat.

In order to maintain a relatively high level of the various substances in the blood and thus insure that these substances would be available in above-normal quantities for the possible synthesis of milk fat, it was deemed

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advisable to administer such substances continuously for a period of 24 or more hours. The technic used for intravenous alimentation proved so satisfactory that it is described in some detail.

The technic consists of fixing a no. 8 or no. 10 rubber catheter in the subcutaneous abdominal mammary vein and connecting this catheter to a drip bottle by means of a gum rubber tube. It appeared advisable to anesthetize the cow. Accordingly, from 3 to 5 g. of nembutal were injected into the jugular vein at a rapid rate. The animal may be thrown or allowed

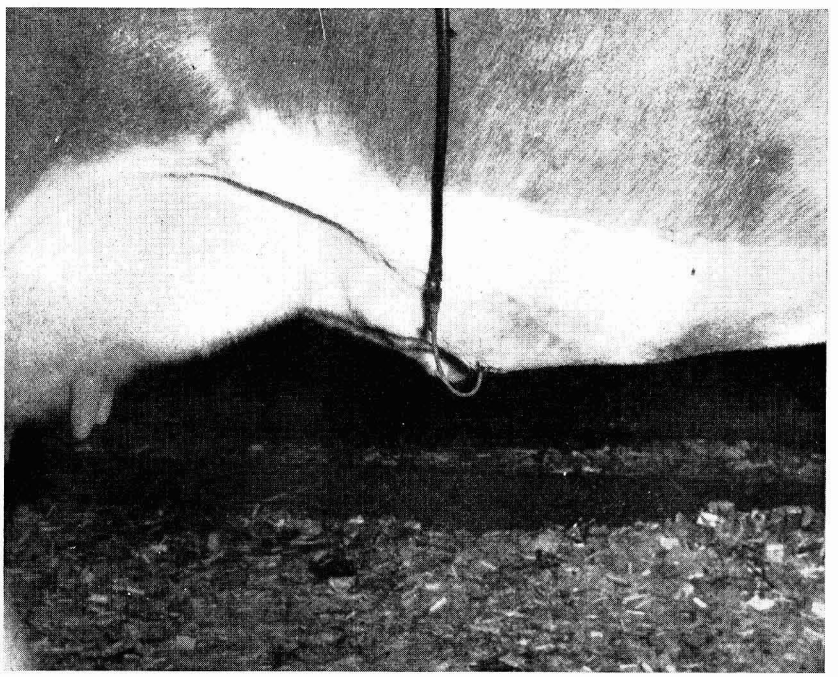

FIG. 1. The rubber catheter fixed in the vein for continuous intravenous feeding.

to fall in a well-bedded stall. It is sometimes necessary to inject an additional gram or so after the cow is in a prone position, particularly if the cow is allowed to become excited. In most cases the operation can be completed without necessitating more than one additional injection.

A small area of the skin, which has been clipped previously, is shaved and an incision approximately 3 cm. in length is made in the skin over one of the subcutaneous abdominal mammary veins. The muscles covering the vein are dissected carefully until a small area of the vein is exposed and a portion is picked up by means of a hemostat. A transverse incision is made in the vein close to the hemostat by means of a small scissors, and approxi-

mately two-thirds of the length of the catheter is inserted into the vein. If the opening in the vein is sufficiently small so that the catheter fits snugly, hematoma will be held to a minimum. Prior to beginning the operation, the clamp on the tube leading from the drip bottle is loosened so that fluid is dripping slowly from the end of the catheter when it is inserted. Three to four sutures are sufficient to close the incision. The first suture is made close to the catheter, knotted and then tied around the catheter to hold it in place. The catheter is shown in place in figure 1.

The tube leading to the drip bottle is attached to the skin by means of

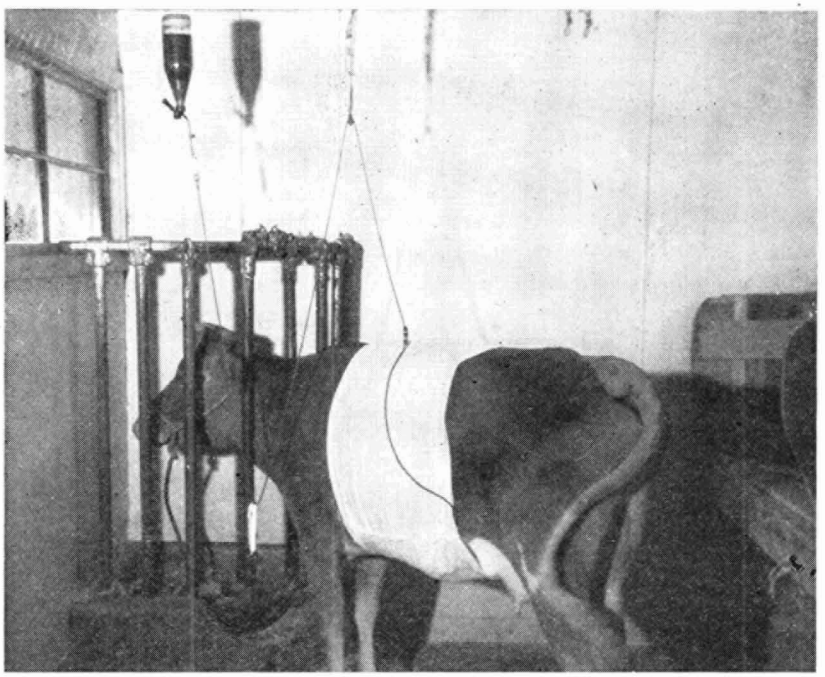

FIG. 2. The arrangement by which continuous intravenous feeding was effected without discomfort to the animal.

sutures, one in the region of the flank and the other over the last rib, approximately half the distance to the backbone. After the cow regains her feet, a wide cloth surcingle is tied around the midsection in order to cover the catheter and the tube leading to the drip bottle. The rubber tube is tied firmly to the surcingle in the region of the loin so that all pull on the tube will be on the surcingle and not on the catheter. From the surcingle the tube passes through a fixed pulley 18 to 24 inches above the backbone of the animal. A sliding weight is placed on the tube between the pulley and the drip bottle with sufficient slack so that the animal can move about and

lie down and get up at will. The details of this arrangement are shown in figure 2.

In the initial studies, goats were fed abomasally by means of a Pezzar catheter fixed in the abomasum and attached to a drip bottle in the manner described above. The abdominal cavity was opened along the ventral midline just posterior to the sternum and the catheter fixed in the abomasum by means of a purse-string suture. The catheter was brought to the exterior through an opening made between two ribs approximately halfway between the midventral line and the dorsal midline, after which the incision along the ventral midline was closed.

The iodine numbers (Hanus) and the Reichert-Meissl and Polenske values were determined on milk fat according to the methods outlined in the Official and Tentative Methods of Analysis (1).

RESULTS

Two goats in milk were fed abomasally. One received glucose and the other triacetin. Nine cows were fed by the intravenous route. The substances administered included glucose, "Pepticase"[3] (a protein hydrolysate), sodium oleate, sodium acetate, and sodium butyrate. The animals usually received grain but no roughage in the last feeding prior to the beginning of the period of intravenous or abomasal feeding.

Fat constants were determined on the purified fat prepared from milk obtained at the beginning and at the usual milking intervals during the experimental periods.

Glucose. Glucose was fed abomasally to a fasted goat and intravenously to two fasted cows, one of which received a protein hydrolysate in addition to the glucose. That the blood glucose level was maintained above normal is evidenced by the fact that in each of the three cases the glucose intake was maintained just slightly below that which produced a mild glucose shock. It is apparent, therefore, that no blood glucose deficiency existed during the fasting periods. In experiment 2 a total of 1985 g. of glucose was injected in 31 hours. It will be noted from the data on experiments 1, 2, and 3 in table 1 that neither the decrease in the Reichert-Meissl values nor the increase in the iodine values was prevented by the administration of glucose.

Protein hydrolysate. Pepticase was administered to one cow by the intravenous route to test the possibility of certain amino acids being involved in the synthesis of the lower fatty acids of milk fat. As blood glucose does not appear to be one of the precursor substances, glucose was administered with the protein hydrolysate with the object of providing additional energy so that the protein hydrolysate would not be utilized too rapidly for energy purposes. During an injection period of 31 hours, a total of 464 g. of Pepticase and 1392 g. of glucose was administered. The Reichert-Meissl value

[3] Supplied through the courtesy of Sheffield Farms Company.

TABLE 1

The effect of intravenous and/or abomasal feeding of glucose, sodium oleate, and a protein hydrolysate to fasted ruminants upon the character of the fatty acids of milk fat

Animal no.	Method of administration	Test substance	Hours after regular feeding	Grams of test substance fed (cumulative)	Milk fat constants			Comments
					R.M.V.*	P.V.†	I.N.‡	
1 (goat)	Abomasal	Glucose 15%	....	.....	22.94	.....	34.74	Normal milk
			18	.....	.....	.....	.....	Started expt. feeding
			24	325	20.06	.....	39.12	
			36	496				
			59	775	17.92	.....	43.12	
2 (cow)	Intraven.	Glucose 20%	.....	.....	24.44	.....	21.95	Normal milk
			23	.....	.....	.....	.....	Started infusion
			39	855	21.49	.....	26.82	
			51	1340	17.07	.....	27.62	
			63	1741	16.73	.....	29.00	
			70	1985	18.29	.....	27.61	
3 (cow)	Intraven.	Glucose (g) 15% and "Pepticase" (p) 5%	....	.....	24.83	.....	22.08	Normal milk
			22	.....	.....	.....	.....	Started infusion
			39	558 (g) 186 (p)	20.32	.....	28.09	
			49	870 (g) 290 (p)	16.68	.....	27.34	
			63	1188 (g) 396 (p)	15.10	.....	24.46	
			70	1392 (g) 464 (p)	14.99	.....	27.37	
7 (cow)	Intraven.	Sodium oleate 5.5%	....	.....	25.19	2.21	37.93	Normal milk
			17	.....	.....	.....	.....	Started infusion
			33	150	21.65	1.35	44.05	

* R.M.V. = Reichert-Meissl values.
† P.V. = Polenske values.
‡ I.N. = Iodine numbers (Hanus).

decreased gradually from 24.83 to 14.99. The iodine value increased from 22.08 to 27.37. These values are fairly representative of changes which would be expected from inanition alone.

Oleic acid. After fasting a cow for 17 hours, 150 g. of sodium oleate in a 5.5 per cent solution were injected by the intravenous route within the following 16 hours. The experiment was terminated when excessive hemoglobinuria was observed. The data presented in table 1, experiment 7, do not indicate that oleic acid had any influence in arresting the changes in the milk fat constants which are typical of fasting.

Acetic acid. Four experiments were conducted to study the possible rôle of acetic acid in the synthesis of the lower fatty acids of milk fat. In one experiment acetic acid was administered abomasally to a milking goat as triacetin. Three cows received sodium acetate intravenously, one receiving sodium butyrate with the acetate. It is evident from the experiments in which acetate was administered alone (experiments 4, 5, and 6, table 2) that the intravenous injection of acetate did not prevent the changes in the milk fat which are typical of fasting.

The amounts of acetate administered are believed to be considerably in excess of that which is normally absorbed into the circulatory system after being produced in the rumen. In experiment 6, a total of 1984 g. of acetate was injected within 22 hours. This experiment was terminated when the cow suffered a temporary collapse resembling tetany. The collapse apparently was due to an alkalosis caused by the metabolizing of the acetic acid, thus freeing an excess of sodium ions in the blood.

Butyric acid. Four cows received sodium butyrate intravenously. Two of the cows received butyrate alone during a period of complete fasting, one received a combination of butyrate and acetate while being fasted, and one received butyrate while on full feed. These animals (nos. 9, 10, 11, and 12, table 3) had been receiving a ration of mixed hay, corn silage, and a 16 per cent concentrate prior to being placed on experiment. To avoid any possible effects of inanition, all four were fed in excess of requirements for a week prior to the experiment. One of the four, no. 12, was fasted without receiving injections of any kind in order to serve as a control for the other three. The fifth cow, no. 8, had been on a regime completely different from the others.

In the first test of butyrate, the results were startling. Cow no. 8 received a total of 1057 g. of sodium butyrate during a period of 29 hours. Not only was the Reichert-Meissl value of the milk fat maintained, but the Polenske value, representing primarily the octanoic and decanoic acids, actually increased from a normal of 2.40 and 2.36 to 2.89 and 2.75. These fat samples were checked repeatedly, without any substantial change in the original values. It will be noted, however, that the iodine values increased by about the same magnitude as that of the milk fat of the control cow.

TABLE 2

The effect of intravenous and/or abomasal feeding of triacetin and sodium acetate to fasted ruminants upon the character of the fatty acids of milk fat

Animal no.	Method of administration	Test substance	Hours after last regular feeding	Grams of test substance fed (cumulative)	Milk fat constants			Comments
					R.M.V.*	P.V.†	I.N.‡	
4 (goat)	Abomasal	Triacetin 5%	.....	.....	22.52	.....	28.86	Normal milk
			17	.....	.....	.....	.....	Started expt. feeding
			24	18	18.75	.....	36.01	
			35	35	16.07	.....	36.22	
5 (cow)	Intraven.	Sodium acetate 15%	.....	.....	19.02	.....	23.92	Normal milk
			17	.....	.....	.....	.....	Started infusion
			24	165	15.64	.....	33.33	
			37	333	13.32	.....	33.69	
			49	668	11.99	.....	38.73	
6 (cow)	Intraven.	Sodium acetate 20%	.....	.....	23.94	1.24	43.25	Normal milk
			19	.....	.....	.....	.....	Started infusion
			41	1984	18.57	0.88	46.14	Symptoms of alkalosis

* R.M.V. = Reichert-Meissl values.
† P.V. = Polenske values.
‡ I.N. = Iodine numbers (Hanus).

TABLE 3

*The effect of intravenous feeding of sodium butyrate and sodium butyrate plus sodium acetate to cows upon the character of the fatty acids of milk fat**

Cow no.	Test substance	Hours after last regular feeding	Grams of test substance fed (cumulative)	Milk fat constants			Comments
				R.M.V.†	P.V.‡	I.N.**	
8	Sodium butyrate 12.6%	....	.....	25.17	2.40	33.03	Normal milk
		7	.....	.....	.....	.....	Started infusion
		11½	100	25.31	2.36	32.14	
		26	589	26.44	2.89	34.84	
		36	1057	25.05	2.75	38.21	
9	Sodium butyrate 12.6%	....	.....	31.10	3.35	33.90	Normal milk
		9	.....	.....	.....	.....	Started infusion
		38	1184	25.02	2.20	42.85	
		49½	1396	20.83	2.17	43.00	Symptoms of alkalosis
10	Sodium acetate 14% (a) plus sodium butyrate 12.6% (b)	....	.....	31.44	2.81	33.55	Normal milk
		8	.....	.....	.....	.....	Started infusion
		15	361 (a) 322 (b)	30.15	3.11	35.07	
		30	1092 (a) 975 (b)	24.02	2.14	39.80	
11	Sodium butyrate 12.6% plus normal ration	....	.....	28.98	3.61	27.85	Normal milk
		4	.....	.....	.....	.....	Started infusion
		11	136	28.92	3.40	28.35	
		38	786	29.45	3.70	26.20	
12	None	....	.....	26.89	2.82	33.35	Normal milk
		13	.....	26.35	3.34	36.90	Complete fasting
		37	.....	17.61	0.92	42.65	

* Cows 9. 10, 11, and 12 received identical rations considerably in excess of requirements for one week prior to the experimental periods.
† Reichert-Meissl values.
‡ Polenske values.
** Iodine numbers (Hanus).

When the experiment was repeated on cow no. 9, the results on the Reichert-Meissl and Polenske values were not duplicated. Instead, the Reichert-Meissl and Polenske values decreased. Similar results were obtained on cow no. 10, which received 975 g. of butyrate and 1092 g. of acetate over a period of 22 hours. Cow no. 11 received a total of 786 g. of butyrate over a period of 34 hours, during which time the animal was on full feed. The butyric acid did not alter the fat constants from the normal values.

Cow no. 12, which had been on a regime identical to that of cows 9 and 10, was fasted completely for 35 hours. The decrease in the Reichert-Meissl value was similar to that observed in cows 9 and 10. The Polenske value showed a more marked change, however, decreasing from 2.82 to 0.92, whereas the fasted cows receiving butyrate decreased from 3.35 to 2.17 in one case and from 2.81 to 2.14 in the other.

DISCUSSION

With neither blood lactic acid nor blood pyruvic acid being utilized in measurable quantities by the active mammary gland of the normal cow (8, 12), the only possible blood carbohydrate which could supply sufficient carbon to account for the lower fatty acids of milk fat is that of blood glucose. The experiments described herein show that when a continuous flow of glucose is administered intravenously at the highest possible rate tolerated by the cow for a period in excess of 2 days, the decrease in the lower fatty acids of the milk fat caused by inanition is not prevented. It must be concluded that blood carbohydrate *per se* is not the precursor of the lower fatty acids of milk fat.

It appears clear that carbohydrate administered orally is not a direct precursor of the lower acids (7), but probably exerts a sparing effect or is converted into the necessary precursors in the alimentary tract.

It is known that the active ammmary gland produces urea (4) and contains arginase (14) which may be used by the gland for the deamination of amino acids. The quantities of amino acids taken up by the gland are sufficient to account for the carbon in the lower fatty acids. This appeared to be a possibility when it was shown that the active gland of the fasted ruminant did not take up the free amino acids from the blood (10, 16). However, the failure of an intravenous administration of a protein hydrolysate to prevent the decrease in the lower fatty acids of the milk of the fasted cow appears to rule out this possibility.

Sodium oleate was fed by the constant flow method to test the earlier hypothesis of Hilditch and Paul (6) and of Shaw and Petersen (15) that the lower fatty acids are derived from the degradation of the longer chain fatty acids. The results do not indicate that the lower acids are derived from oleic acid. However, the amount of oleate injected was necessarily small and definite conclusions probably are not warranted.

In view of the recent work showing that acetic acid is used in the synthesis of fatty acids, this substance appeared to offer considerable promise as a precursor of the lower fatty acids of milk fat, since it is formed in the rumen in considerable quantities. Further, such synthesis would explain the ability of food carbohydrate but not blood carbohydrate to serve as the precursor of the lower acids. However, the Reichert-Meissl and Polenske values on milk fat from fasted ruminants receiving considerable acetic acid abomasally and intravenously were typical of fasted animals.

Butyric acid, being produced in the rumen by the fermentation of carbohydrate, appeared to be another possible precursor substance. Four cows received relatively large quantities by the intravenous route. The results are conflicting. In one case there was actually an increase in the Polenske value, and the normal Reichert-Meissl value was maintained even though the cow was fasted. These results were not duplicated in succeeding experiments, although the Polenske value of the milk fat of the two additional fasted cows receiving butyrate did not decrease nearly so much as in the case of a fasted control cow. While no conclusions appear to be warranted, the data do suggest some interesting possibilities.

It may be that the butyric acid was being converted to acetone bodies and burned at such a rapid rate that little reached the mammary gland except in the one case. The same could also apply to acetic acid. On the other hand, if butyric acid was being made available to the gland in these experiments and was not being incorporated into the triglyceride, it will necessitate thinking in terms of something more complicated than a simple recombination of glycerol and fatty acids in the formation of the triglycerides of milk fat.

There has been considerable disagreement as to whether blood carbohydrate is the precursor of the lower fatty acids of milk fat. Because of the considerable amount of data which has been accumulated in the past few years in studies concerned with this possible relationship, and because of the rather conclusive negative data reported in this paper, it may be well to examine and summarize the data collected to date.

The suggestion that the lower fatty acids of milk fat are synthesized directly from carbohydrate is based entirely upon the reports that the respiratory quotient of the normal active gland of the ruminant exceeds unity (3, 9, 12) and that the respiratory quotient of the gland of the fasted ruminant is less than unity (9, 16). It is pointed out that these two findings coincide with the fact that fasting decreases the short-chain fatty acids as well as the carbohydrate content of the body. The high respiratory quotient (RQ) of the active normal gland, which was first reported by Graham *et al.* (3), appears to be established fairly well. The reports by Reinecke *et al.* (9) and by Shaw *et al.* (16) that the RQ of the gland of the fasted ruminant is less than unity, are based on only a few observations.

Because of the difficulty involved in obtaining representative RQ's on the gland, many more data are needed to establish the latter with certainty. In addition, Reinecke *et al.* reported that 48 hours or more of fasting were required to produce a low RQ. It is difficult to correlate this with the fact that the greatest decrease in the lower fatty acids occurs within the first 24 hours of fasting. However, assuming that the RQ of the gland of the fasted ruminant is low, what does it represent in terms of the metabolism of the gland?

In the first place, most investigators have been unwilling to accept the RQ alone on any particular organ as proof of the type of metabolism taking place within that organ. Recent work showing that carbon dioxide actually is used in synthesis within the body has tended to confirm this view. Secondly, there is considerable doubt of a true metabolic relationship between the decrease in the lower fatty acids and fasting on the one hand, and the lowering of the RQ of the gland reported for the fasted ruminant on the other, since it has not been possible to demonstrate a consistently low RQ for the glands of cows in which the lower acids had been decreased markedly by the feeding of cod-liver oil (12).

Even if it were possible to establish such a relationship, it must be kept in mind that neither the feeding of cod-liver oil nor fasting decreases the lower acids more than 35 to 40 per cent. If the lower fatty acids are synthesized from carbohydrate, how then can we account for a low RQ with 60 per cent or so of these acids still being so synthesized?

The amount of glucose available to the gland for the synthesis of fat appears to be entirely insufficient for the synthesis of the lower fatty acids. Graham first attempted to measure the blood flow in relation to glucose uptake by the gland, using the thermostromuhr method, and concluded that the glucose uptake was insufficient to account for more than 50 per cent of the milk lactose (2). At the time it was believed that the thermostromuhr method of measuring blood flow in vivo was quite accurate. However, very exhaustive experiments by Gregg *et al.* (5), Shipley *et al.* (18), and Shipley and Gregg (17) have shown that such is not the case. They obtained errors as great as 300 per cent and stated that " . . . the flow of blood in an artery of an animal can only by chance happening be determined from a unit applied to it which had been previously calibrated in an artificial circulation system . . . this is so, because, for the same unit it is indeed an accident when in vitro and in vivo environments influence the differential temperature-flow relations in the same direction and to the same extent."

By determining the calcium, inorganic phosphorus, and glucose uptake by the gland and the total amount of calcium, phosphorus, and lactose secreted during a 24-hour period, it was possible to calculate the blood flow, the total amount of glucose utilized by the gland, and the amount of glucose available for other purposes after accounting for lactose (16). Five such

experiments showed a blood flow of 494 volumes for each volume of milk formed, with a range from 408 to 561. The glucose uptake was sufficient to account for 105.5 per cent of the milk lactose. In the five experiments it was found that the glucose uptake was sufficient to account for 81.4, 101.2, 115.4, 115.3, and 97.9 per cent of the lactose secreted.

As any mammary gland balance must depend upon the accuracy of the arteriovenous determinations in representing the true metabolism of the gland, this method of approach is subject to a great deal less error than the thermostromuhr method. The accuracy of a mammary gland balance based on the thermostromuhr method is dependent upon whether the arteriovenous differences represent the true average uptake by the gland as well as the accuracy of the determination of the rate of blood flow. The large errors reported for the latter method are much greater than that which would be expected where the rate of blood flow is calculated from the uptake of calcium and phosphorus and the total amount of calcium and phosphorus secreted in the milk as shown by the actual analysis of the milk.

Data obtained by Shaw and Petersen (15) and Shaw, Boyd, and Petersen (13) can be used to make similar calculations, although in this case the average analysis of milk must be used, and the blood calcium and glucose uptake do not necessarily represent the same cow or experiment. However, the values are sufficiently numerous and uniform to obviate gross errors. Twenty arteriovenous differences for plasma calcium averaged 0.31 mg. per cent. Converting this to whole blood values on the basis of a 30 per cent cell volume, the difference becomes 0.217 mg. per cent. Assuming that the average calcium content of the milk is 120 mg. per cent, the ratio of calcium in the milk to calcium uptake becomes 553 to 1. The average of 40 determinations of the glucose utilization by the gland was 9.3 mg. per cent. At a ratio of 553 volumes of blood to one unit volume of milk, the glucose uptake could account for 5142 mg. per cent of lactose. With an average lactose content of 4900 mg. per cent in milk, this represents sufficient glucose to account for approximately 105 per cent of the lactose. The five complete balances of Shaw *et al.* (16) are in good agreement with these calculations. The complete balance experiments included fat. To account for the lower fatty acids in these trials, the data show that from 25 to 30 per cent of the glucose would be needed if we are to postulate that the lower fatty acids are formed from carbohydrate. Even with the small amount of glucose taken up as glyco-protein (10), it appears obvious that with neither blood lactic acid nor pyruvic acid being utilized by the gland, the gland does not remove sufficient carbohydrate from the blood to account for both lactose and the lower fatty acids.

Also opposed to the suggestion that fasting causes a decrease in the lower acids by depleting the carbohydrate available for the synthesis of these acids, is the finding that the gland of the cow with ketosis continues to remove a

normal amount of glucose from the blood even when the blood glucose falls as much as 50 per cent (11), a value much lower than would be attained by two days of fasting. Further, it was observed that even such low values were not associated with a decrease in the lower fatty acids in those cases of ketosis in which the animals retained their appetites, indicating a relationship between feed intake and the lower acids, but not between blood glucose and these acids.

Finally, with the data reported in this paper to the effect that the maintenance of the blood glucose of the fasted cow at a high level does not prevent or retard the decrease in the lower fatty acids, the evidence against the postulation that these fatty acids are synthesized in the gland from carbohydrate appears to be conclusive.

SUMMARY AND CONCLUSIONS

1. A technic was developed for the continuous intravenous feeding of ruminants.

2. The continuous intravenous injection of cows with a protein hydrolysate, glucose, oleic acid, and acetic acid failed to prevent the decrease in the lower fatty acids of milk fat caused by fasting. As much as 1984 g. of sodium acetate was administered in 22 hours and as much as 1985 g. of glucose was administered in 31 hours.

3. A summary of the work to date renders the theory of a blood carbohydrate origin of the lower fatty acids extremely unlikely.

4. The data obtained from the continuous injection of butyric acid are inconclusive.

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THE REMOVAL OF THE SORBED GASES IN DRIED MILKS[1]

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INTRODUCTION

The results of experiments initiated in 1942 (2) on dried milks packed in air and in inert gas indicated that the keeping quality of the products packed in an inert gas atmosphere of which the final oxygen concentration was 3 to 4 per cent was considerably greater than that of the products packed in air (20.9 per cent oxygen). Although the keeping quality of dried milk depends to a great extent on the freshness of the liquid milk used and the methods employed in its desiccation, the improvement in keeping quality that was effected by reducing the oxygen concentration of the containers was so marked that recommendations were made for the consideration of this method of packing for all dried milks which had to undergo rigorous conditions of storage, especially those destined for overseas use (4). Reduction of the oxygen concentration in the commercial containers to values of less than 3 per cent did not seem practical at that time. The results of Lea, Moran, and Smith (3) published in 1943 indicated also that the keeping quality of dried milks was increased when the oxygen concentration within the dried milk containers was decreased. Subsequent studies (1, 5, 6) confirmed these observations and indicated the methods necessary to obtain oxygen concentrations of different values.

Although the practice of packaging dried milk in atmospheres of reduced oxygen concentration had been used to a limited extent for some time in the industry when this work was begun, information was lacking on the amounts of gases held in dried milks by various forces, the factors that are concerned in the removal of these gases, and the relative effect of different oxygen concentrations on keeping quality.

Spray-dried milks are composed of finely divided and very porous particles and, therefore, have enormous total surface areas (internal as well as external) per unit weight of product. Thus it seems that gases may be held by the particles by adsorption and by occlusion, and in the fat by absorption. In the following discussion these gases, however held, will be considered together under the designation of sorbed gases.

Aside from the specific characteristics of a porous material, the temperature, time, and degree of evacuation are important factors in the removal of

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sorbed gases. Hence, the effect of variations in these factors, as well as of the moisture content, on the amount of sorbed gases was studied to determine the relative importance of each factor and to determine the practical conditions that may be employed to remove these gases from dried milks.

APPARATUS AND ITS OPERATION

A diagram of the apparatus used throughout these studies to remove the sorbed gases, measure their volume, and determine their composition is shown in figure 1.

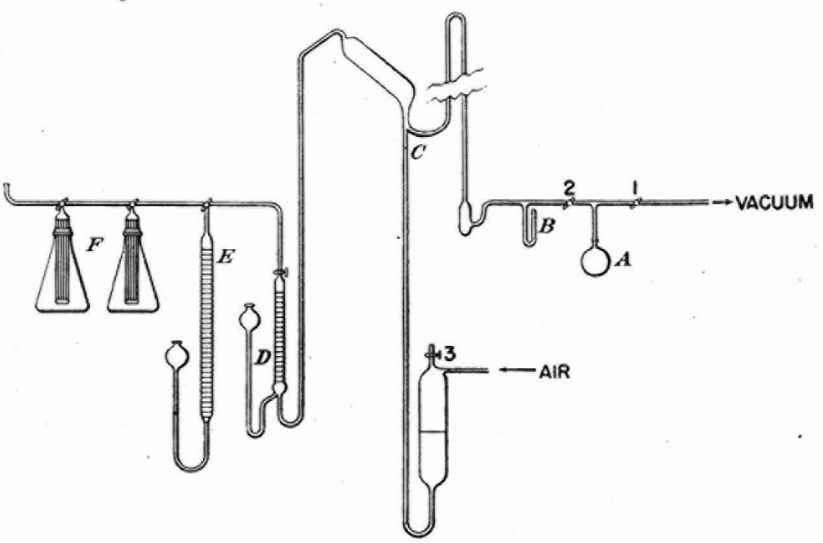

FIG. 1. Toepler pump and gas analysis system.

A is a 500-milliliter ground-glass-joint flask that may be immersed in a constant-temperature bath. *B* is a mercury manometer, *C* a Toepler pump, *D* the gas burette, *E* the gas-collecting chamber of the gas analysis apparatus, and *F* the absorption system, consisting of a carbon-dioxide absorption burette containing potassium hydroxide and an oxygen-absorption burette containing alkaline pyrogallol solution. The manifold system is made of capillary tubing and the horizontal portion is mercury filled. The absorption burettes and the gas burette are connected to the manifold by three-way T stopcocks.

The flask *A* containing the 225 g. sample was immersed in a bath held at the desired temperature. The oil vacuum pump was then operated and the sample evacuated for the desired period of time at the desired degree of vacuum. When the vacuum required was less than the full vacuum of the pump, it was obtained by adjusting stopcock 1 and observing the manometer *B*, stopcock 2 being open to the Toepler system. After the desired vacuum

treatment, stopcocks 1 and 2 were closed and the Toepler system completely evacuated by operating stopcock 3. Stopcock 2 then was opened and the residual sorbed gas in the sample was desorbed over a period of about 6 hours by heating the sample in *A* to 70° C. (or higher) and operating the Toepler pump at intervals of about 30 minutes to remove the gas and store it in burette *D*, where it was measured. When it was desired to analyze the desorbed gas, it was transferred to burette *E*, where it was then measured both before and after absorption of the carbon dioxide and the oxygen in the appropriate solutions.

EXPERIMENTAL

In the following discussion the term "residual gas" has been used to designate the gases which can be removed from the system as indicated above after a given evacuation procedure has been used. The total amount of residual gases consists of the free gases remaining in the system plus the sorbed gases which can be removed from the product. After an evacuation at a vacuum of 3 to 5 mm. pressure, the amount of free gas in the container is but a small proportion of the total amount of residual gas. The proportion increases as the degree of evacuation decreases.

The amount of residual gas in a container varies with the efficiency of the evacuation process, *i.e.*, degree, temperature, and time of evacuation. The amount of residual gas which can be removed with a Toepler pump varies with the temperature at which the product is held, the time of evacuation, and the physical structure of the product.

At a given temperature the amount of residual gas obtained with a Toepler pump during the first interval of time is relatively large and decreases with each successive interval. After 6 hours the amount obtained at each interval is very small and practically a constant. The total amount obtained during 6 hours was considered the residual gas content of the product.

If the temperature of the product during desorption is increased, the amount of residual gas increases as indicated in figure 2.

At temperatures greater than 70° C., although larger volumes of gas are obtained, slight discoloration of the product occurs, suggesting slight decomposition. A temperature of 70° C. was therefore chosen as that at which desorptions were to be carried out.

Although the total amount of sorbed gases was not removed under these conditions, the values obtained are comparable. From data obtained it was estimated that approximately 80 per cent of the residual gas was removed in the manner prescribed, at 70° C.

The Effect of the Temperature of the Product during Evacuation upon the Amount of Residual Gas

An increase in the temperature usually decreases the amount of gas adsorbed by a porous material. Samples of dried milk were treated at a

vacuum of 10 mm. pressure for 10 minutes at temperatures of 20°, 30°, and 40° C., respectively, and the amount of residaul gas then determined as previously described. The amounts of residual gas obtained at 30° and 40° C. were slightly but not significantly less in each case than the amount obtained at 20° C. However, when short periods of evacuation and products of moisture contents greater than usual are concerned, the efficiency of evacuation will be affected by the vapor pressure of the product, this pressure increasing with temperature. Under these conditions the efficiency of the process may be less at the higher temperatures. One-half-pound samples

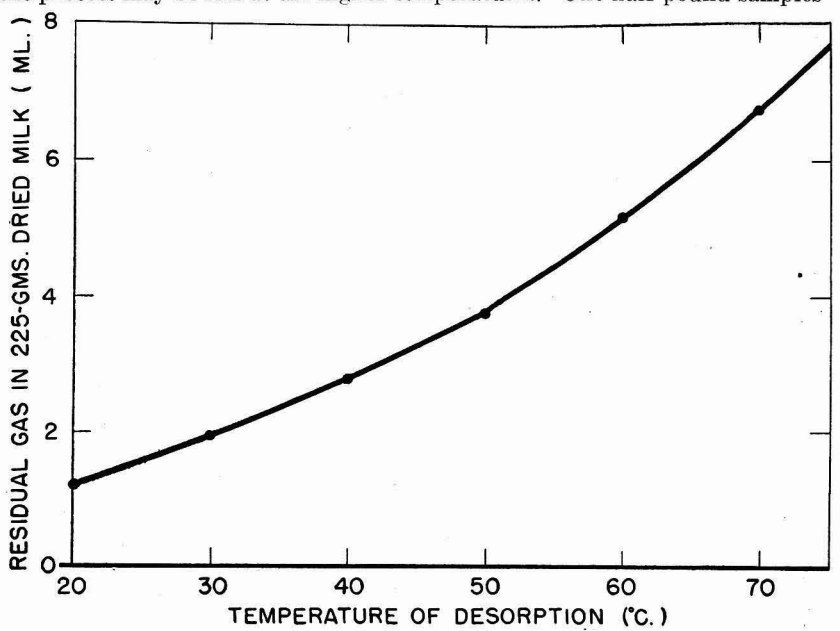

FIG. 2. Amounts of gas obtained at different temperatures of desorption.

of a commercial dried milk were subjected to the vacuum of an oil pump for 3 minutes at 20°, 30°, 40°, and 50° C., respectively, and the actual vacuum attained in the system was noted. The values are shown in figure 3. Under similar conditions of evacuation, a number of tins of dried milk were packaged in nitrogen. After storage of 3 days at room temperature, the gases in the head space of the cans were analyzed. The average oxygen percentages of the gas in the cans evacuated at the different temperatures are shown in figure 4. It is evident that the values obtained are those which can be obtained only under the conditions used. They will differ with the moisture content of the product, the time of evacuation, the capacity of the pump used, and other factors. However, the results do emphasize the fact that

increasing the temperature at which the product is held does not necessarily increase the amount of gas removed by evacuation.

The Effect of the Time of Evacuation upon the Amount of Residual Gas

It is logical to assume that the longer a dried milk is held under a vacuum the less will be its residual gas content.

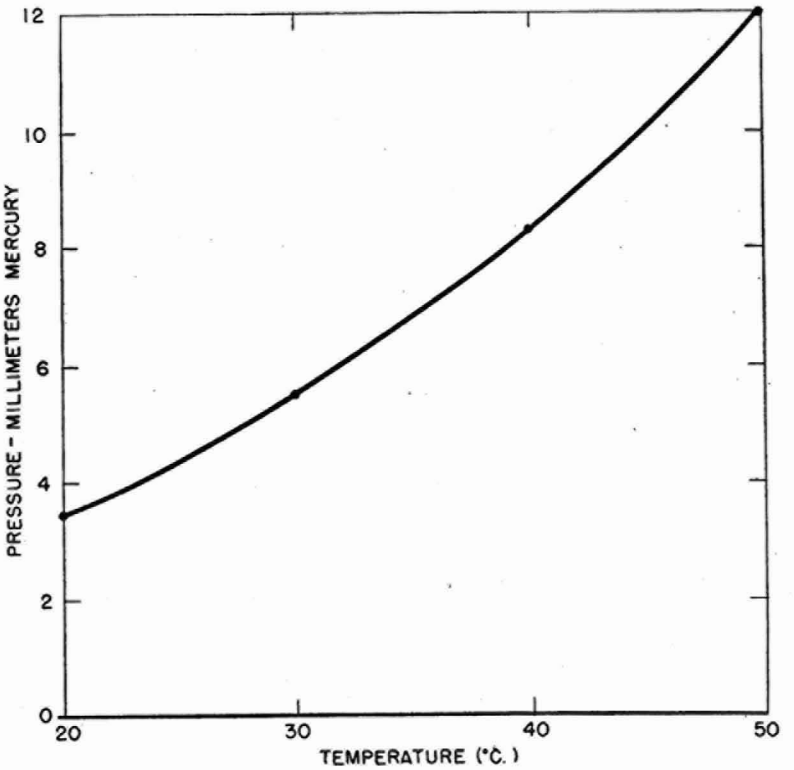

FIG. 3. Manometric pressure obtained by evacuation of dried milk for 3 minutes at different temperatures.

Figure 5 shows the results on an old sample of dried milk after treatment at various degrees of vacuum at room temperature. The values shown indicate that from 15 to 30 minutes is required to evacuate dried milks to a point where additional evacuation will produce only a small regular decrease with increase in pumping time. As expected, the amount removed increases with the time of evacuation, and increases more at the higher degrees of evacuation.

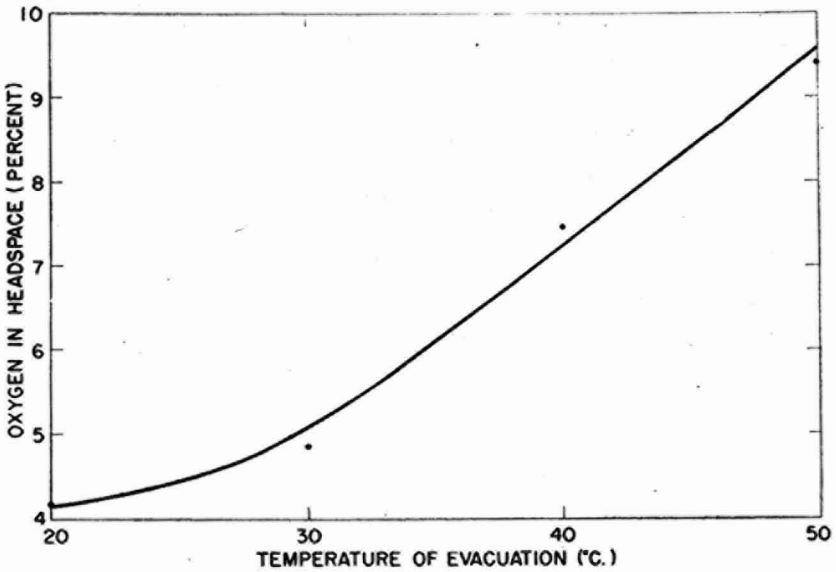

FIG. 4. Oxygen percentage in dried milk containers evacuated for 3 minutes at various temperatures.

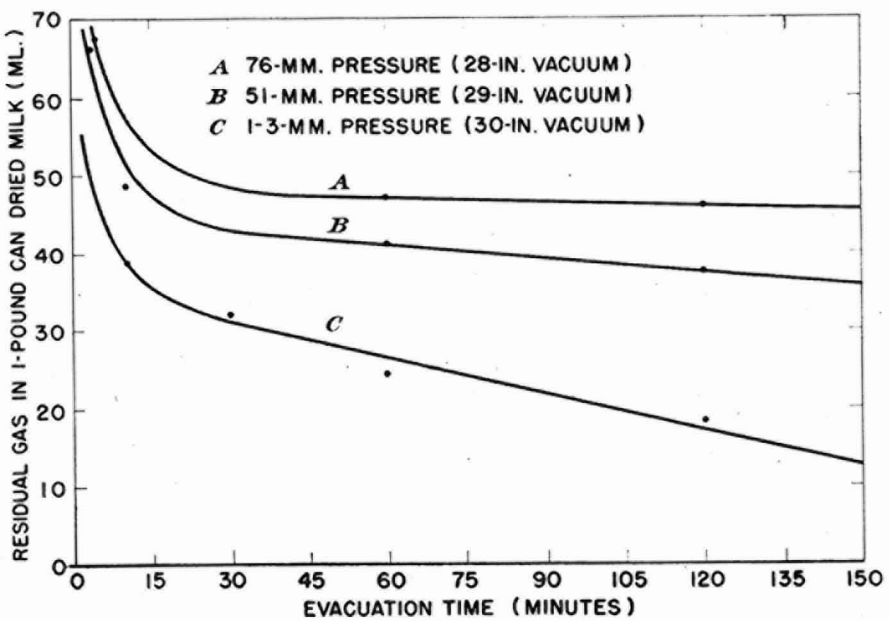

FIG. 5. Amounts of residual gas obtained from dried milks evacuated at different degrees of vacuum for different periods of time.

Effect of the Degree of Vacuum Used upon the Amount of Residual Gas

The time of exacuation used in these experiments was 10 minutes, the temperature 25° C., and the degree of vacuum 10 mm. pressure of mercury. The results are given in figure 6.

It is apparent from these data that the amount of sorbed gas decreases but slightly as the degree of vacuum increases from 51 to 3 mm. of pressure. The amounts of gas removed (B) at 25° C. represent the gas in the free space of the container after evacuation under the given conditions. The

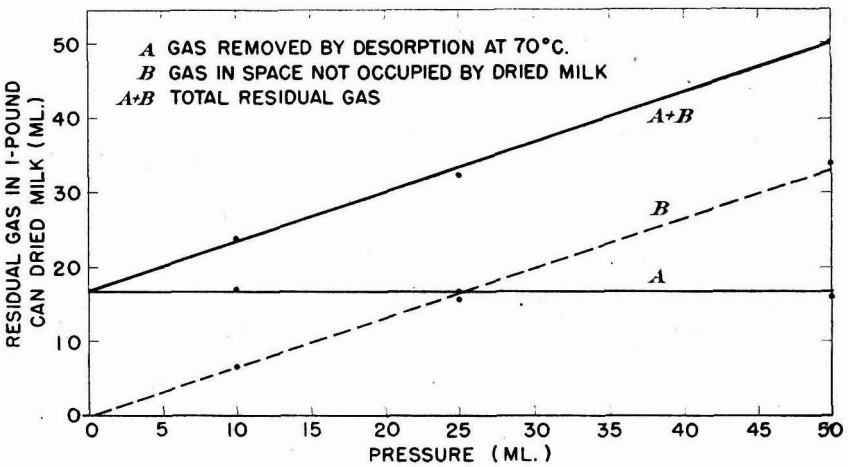

FIG. 6. Amounts of residual gas in dried milks evacuated at different degrees of vacuum.

values represented by A are the amounts of sorbed gas obtained when the temperature was increased to 70° C. The total amounts of residual gas are represented by $A + B$.

From the data presented it is evident that increases in time, temperature, and pressure of evacuation beyond practical values do not decrease greatly the amount of the sorbed gases held by the product. However, the desirability of the use of as complete a vacuum as possible is indicated in figure 6. At vacuums of several millimeters pressure, the amount of gas in the free space is, of course, very small. At 25 mm. of pressure it is approximately 17.50 ml. or 3.65 per cent of the free space in a 1-lb. container and is approximately equal to the amount of residual gas in the dried milk which can be removed by heating the product to 70° C. Upon evacuation at a vacuum of 51 mm. pressure, the amount of gas in the free space is approximately twice that of the residual gas.

Effect of the Concentration of the Milk upon the Residual Gas of Its Dried Product

It had been noted in preliminary experiments that dried milks made by different methods and of different degrees of fineness differed greatly in the amounts of residual sorbed gases. Samples of dried milk therefore were prepared from milks of different degrees of concentration varying from

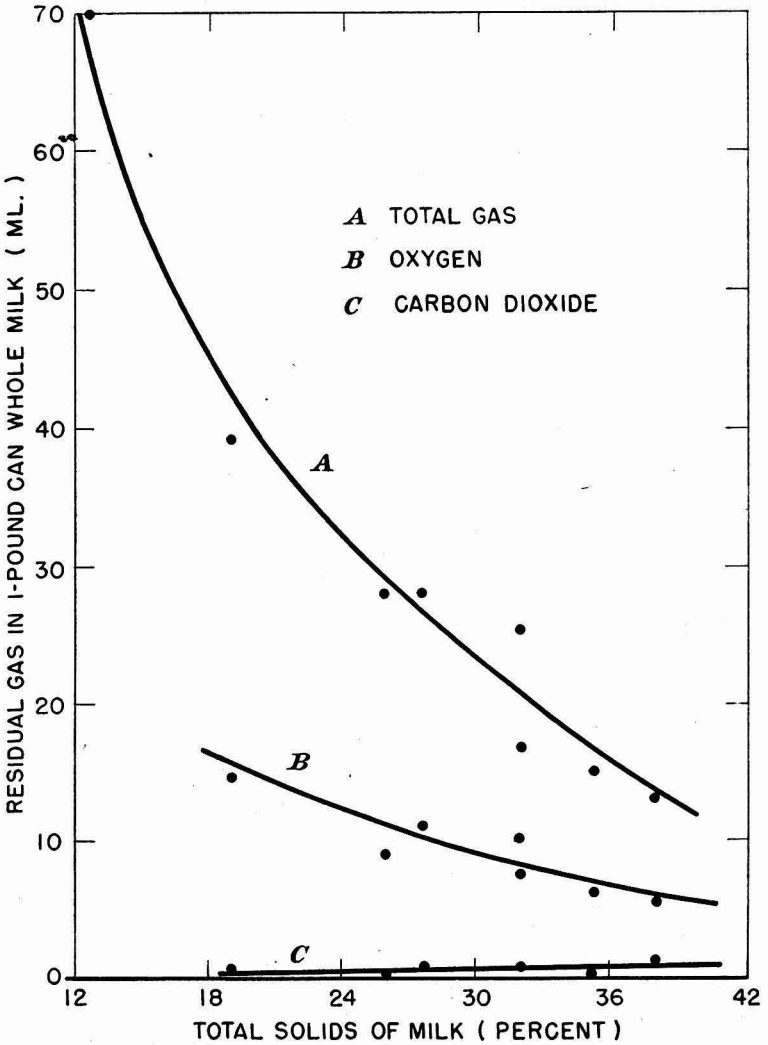

FIG. 7. Residual gas in dried milks prepared from milks of different concentration.

13 per cent to 38 per cent solids. The product made from milk of 13 per cent solids was finely divided and of low apparent density. As the concentration of the milk increased, the dried milks became coarser in texture and of greater apparent density. The results on determinations of residual gases in these samples are given in figure 7.

The amounts of residual gas, or gas which remained in the products after treatment at full vacuum of an oil pump for 1 hour at 25° C., decreased rapidly with increases in the solids concentration of the milk used. The decrease in the amounts of oxygen was relatively smaller.

Effect of Moisture Content upon the Amount of Sorbed Gases

A series of experiments was conducted to determine the effect of variations in the moisture content on the amount of sorbed gases remaining in dried milks after vacuum treatment. Samples of two dried milks containing less than 2 per cent of moisture were allowed to absorb moisture from relatively humid atmospheres until the desired moisture content was obtained

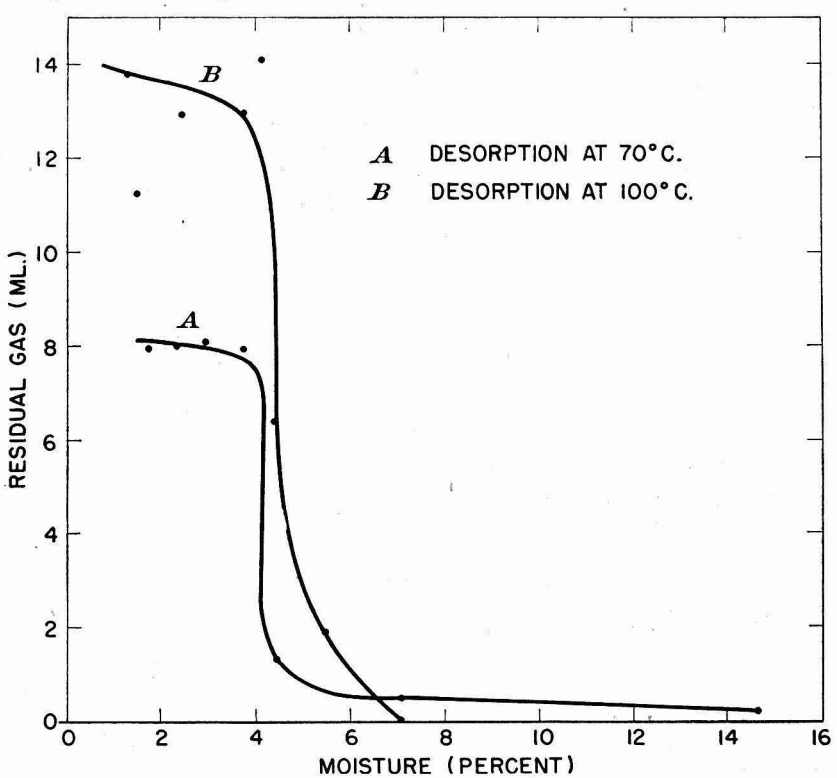

FIG. 8. The residual gas in dried milks of different moisture percentage.

in each case. Samples ranging in moisture content from the original amount to over 7 per cent were obtained in this manner. Each sample was subjected in turn to the full vacuum of an oil pump for 1 hour at 25° C., with an anhydrous magnesium perchlorate desiccant inserted between the sample and the remainder of the system. The residual gas of each sample was then determined with the temperature of the sample maintained at 70° C. The results are shown in figure 8.

Within the range of moisture content of commercial dried milks the amount of sorbed gases differed but slightly with differences in the moisture content. However, if the products absorbed moisture to amounts greater than 4 per cent, there was an abrupt decrease in the amount of sorbed gases. Whether the absorption of moisture facilitates in some manner the removal of gases during evacuation or whether the moisture is adsorbed preferentially has not been determined.

Diffusion of Sorbed Gases

To what extent the sorbed gases can be removed by the removal of nitrogen into which these gases have been allowed to diffuse for a period of time was determined.

TABLE 1

Percentage composition of gas in container after successive evacuations, filling with nitrogen, and storing for different periods of time

Period	Nitrogen	Oxygen	Carbon dioxide
	(%)	(%)	(%)
1st (3 days)	97.8	2.2	Trace
2nd (3 days)	99.6	0.4	Trace
3rd (4 days)	99.8	0.2	Trace
4th (3 days)	100.0	Trace	Trace
5th (4 days)	100.0	Trace	Trace

A freshly made sample of 225 g. of dried milk quickly was brought to full vacuum with the oil and Toepler pumps. Nitrogen then was bled into the system until the system was brought to atmospheric pressure; the sample was allowed to remain under these conditions for 3 days. A sample of the gas in the system then was withdrawn and analyzed, and the system again evacuated and filled with nitrogen. This cycle of procedure was repeated until the percentage of oxygen content of the nitrogen admitted was practically zero. The results are shown in table 1.

After five stages of evacuation the system containing the sample was evacuated quickly again with the oil and Toepler pumps to rid it completely of free gases. The sample container then was immersed in a bath maintained at 70° C. and the liberated gases were removed with a Toepler pump and analyzed.

The amount obtained was 6.15 ml., which is equivalent to 70.1 per cent

of the amount of sorbed gases that were removed from another sample of the same milk under similar conditions, except that no diffusion was allowed to occur. The composition of the residual gas obtained after the five successive evacuation and diffusion periods was as follows: Nitrogen, 95.9 per cent; oxygen, 4.1 per cent; carbon dioxide, trace. Hence, it is indicated that although all of the oxygen cannot be removed except by continued exhaustive removal by desorption and evacuation extending over a long period of time, the amount of oxygen which remains in the residual gas after two cycles of this process is relatively small.

Percentage Composition of the Residual Gas

Aside from the amounts of gas retained by the dried milks after evacuation, the oxygen concentration in this gas is of interest. In table 2 are shown the results of analyses of the residual gases from two freshly made and three relatively old samples of dried milk.

TABLE 2

Composition of residual gases from representative samples of dried milk

No.	Description of sample	Oxygen	Nitrogen	Carbon dioxide
		(%)	(%)	(%)
1	Freshly made. Evac. 29.6 in., 10 min., at 25° C.	32.7	68.9	1.4
2	Freshly made. Evac. 29.6 in., 15 min., at 25° C.	39.0	61.0	0.0
3	Old sample. Evac. 30 in., 5 min., at 25° C.	25.6	65.0	9.4
4	Same as no. 3. Evac. 30 in., 10 min., at 25° C.	22.0	68.9	9.1
5	Same as no. 3. Evac. 30 in., 45 min., at 25° C.	23.7	66.1	10.2

The values in table 2 indicate that the amount of residual oxygen is relatively high and that of carbon dioxide is practically nil in freshly made dried milk. In aged samples the proportion of oxygen is less and the carbon dioxide considerably more than in freshly made dried milks. Also, the proportion of carbon dioxide in the residual gas is considerably more than would be expected if only the partial pressures of this gas in the atmosphere were concerned. However, carbon dioxide is adsorbed more strongly than the other gases concerned and therefore seems to concentrate in the product with a resulting displacement of other gases, in this case evidently oxygen.

These results support the belief that adsorption is a vital factor in the retention of gases by dried milks. If occlusion alone were concerned, the percentage composition of the gases would be that of the air used in the drying procedure and also would not vary greatly with the age of the product. The release of oxygen by the product with age is of interest. To what

extent it can enter into consideration in practical procedures requires further study.

DISCUSSION AND SUMMARY

The amount of sorbed (occluded, adsorbed, and dissolved) gases in dried milks varies greatly with the fineness of the product. Dried milks made from milks of normal concentration contain a relatively large amount of sorbed gas, which decreases greatly as the concentration of the milk used is increased from 9 to 38 per cent solids.

A large percentage of the sorbed gases can be removed by evacuation for relatively short periods of time within the practical range of temperatures of 20° to 40° C. The remainder only can be desorbed very slowly as the time of evacuation is extended.

The composition of the sorbed gas varies with the storage time of the dried milk in an atmosphere of air. Freshly made products seem to have percentage concentrations of oxygen greater than air and very low percentage concentrations of carbon dioxide. In older products, the proportion of oxygen in the sorbed gases is but slightly greater than that in air and the proportion of carbon dioxide is greater than can be accounted for if the gases are occluded air.

The results indicate that most of the residual gases are held by adsorption forces.

A large proportion of the oxygen of the sorbed gas may be removed by successive evacuations, with periods of several days between to allow for diffusion of the oxygen into a nitrogen atmosphere. The results indicate that two cycles of evacuation—filling with nitrogen, and holding for 3 to 4 days—remove a high percentage of the oxygen of the sorbed gases.

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ASSOCIATION ANNOUNCEMENTS

The Annual Meeting of the American Dairy Science Association will be held at Ontario Agricultural College, Guelph, Ontario, June 24, 25, and 26, 1947. Further information concerning the meetings will appear in later issues of the JOURNAL.

D. M. Seath, chairman of the Production Section, has appointed the following men to the Committee on Dairy Cattle Judging Contests: S. M. Salisbury, Ohio, *Chairman;* D. L. Fourt, Idaho; and R. E. Johnson, Connecticut.

The membership of the Honors Committee, as listed on page 66 of the January issue of the JOURNAL, was incorrect. The members of this committee are: A. C. Dahlberg, New York, *Chairman;* A. C. Ragsdale, Missouri; and J. A. Nelson, Montana.

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ABSTRACTS OF LITERATURE

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MILK AND MILK PRODUCTS

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1001 Fifteenth Street, N.W., Washington 5, D. C.

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JOURNALS

American Butter Review
American Milk Review
American Journal of Diseases of Children
American Journal of Physiology
American Journal of Public Health
Archives of Pediatrics
Australian Journal of the Council for Scientific and Industrial Research

Biochemical Journal

Canadian Dairy and Ice Cream Journal
Canadian Journal of Public Health
Canadian Journal of Research
Certified Milk
Cornell Veterinarian

Dairy Industries
Dairy World

Endocrinology

Food in Canada
Food Industries
Food Manufacture
Food Research

Ice and Refrigeration
Ice Cream Field
Ice Cream Review
Ice Cream Trade Journal
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New Zealand Journal of Science and Technology

Nordisk Mejeri-Tidsskrift

Pacific Dairy Review
Proceedings of Society of Experimental Biology and Medicine

Refrigerating Engineering

Scientific Agriculture
Southern Dairy Products Journal

SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment, Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers
Milk Industry Foundation

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

59. **Comparison of Resazurin Test with Methylene Blue.** G. OKULITCH, R. MILLARD, AND O. FLEMING. Canad. Dairy and Ice Cream Jour., *25,* 11 : 35. Nov., 1946.

Milk can be graded effectively by means of the resazurin test using a single color standard, mauve pink no. 12 or Munsell notation P.R.P. 7/8, and making readings at 1 and 3 hr. The resazurin test and the methylene blue test agree well in selecting poor-quality raw milk. The correlation of resazurin and methylene blue is approximately 80%. Both the standard plate count and the direct microscopic count support the resazurin test in more cases than they do the methylene blue test. A high percentage of samples that test 3 hr. or more with resazurin have counts of less than 200,000 per ml. by the plate method and less than 100,000 by the direct microscopic procedure. A resazurin mauve pink of 3 hr. or more represents as good-quality milk as a 6.5-hr. methylene blue test. A greater number of physiologically or pathologically abnormal milks may be detected by the resazurin test as compared to the methylene blue test. By using the resazurin test a greater saving of time is effected. H.P.

60. **Thermal Death Range of Bacteria in Milk.** F. W. GILCREAS AND J. E. O'BRIEN, Research Laboratories, New York State Department of Health, Albany, N. Y. Jour. Milk Technol., *9,* 5 : 269–272. Sept. and Oct., 1946.

See Abs. 21, Jour. Dairy Sci., *30,* 2 : A14. Feb., 1947.

CHEESE

61. **Factors Influencing Acid Production by Cheese Cultures. I. Effect of Cooking Temperatures on Acid Production in the Manufacture of Cheddar Cheese.** F. J. BABEL, Iowa Agr. Expt. Sta., Ames. Natl. Butter and Cheese Jour., *38,* 1 : 34. Jan., 1947.

An abbreviated form of the original publication in Jour. Dairy Sci., *29,* 9 : 589. Sept., 1946. W.V.P.

62. **Making Process Cheese in Small Plants.** C. R. BARKER, Oak Park, Ill. Natl. Butter and Cheese Jour., *37,* 12 : 90. Dec., 1946.

Cheese that has been aged for 30 days at 60° F. without paraffin can be used to make a satisfactory processed cheese. Water lost in curing is replaced during processing. In blending, there should be 50% of cheese

"on the sweet side" and 50% "on the acid side". Cooking this blend of cheese with water in the jacket of the cooker at a pressure of 10 lbs. and a temperature of 239° F. is recommended. (No warning is given concerning ability of the cooker to stand the pressure.) W.V.P.

63. Practical Suggestions on the Manufacture of Process Cheese. C. R. BARKER, Oak Park, Ill. Natl. Butter and Cheese Jour., *38,* 1: 42. Jan., 1947.

Cheese made in a single factory can be processed successfully if some is made "on the acid side" and some "on the sweet side". Vat drippings of 0.9% before salting give cheese of the acid type. Such cheese should constitute 30–40% of each batch, while the remainder should be "sweet" from curd with vat drippings of 0.6% at salting. Tough, over-cooked Cheddar is not desirable. The usual cleaning and cooking operations are described very briefly. A diagram illustrates the flow of material through the operations of curing, grading, blending, cleaning, grinding, cooking, packaging, cooling, and shipping. W.V.P.

CHEMISTRY

64. Some Chemical Changes Produced in Milk by High Temperature Heat Treatment. IRA A. GOULD, JR., Dairy Dept., University of Maryland. Milk Plant Monthly, *35,* 9: 70–71. Sept., 1946.

The author reviews brifly results of his research in this field during the past 12 years, pointing out the relationships between the boiled or cooked flavor of milk and some chemical changes bringing out these flavors. The cooked flavor was caused by the formation of sulfhydryl compounds, usually accompanied by the evolution of hydrogen sulfide gas at temperatures of 168.8–172.4° F. These chemical changes become more pronounced as the temperature increases to boiling. Serum proteins were undoubtedly the principal contributors to the formation of the heat-labile sulfides. Extremely small quantities of metallic salts of mercury, silver, ferric iron, and copper influence sulfide liberation. Additions of small percentages of sucrose, glucose, and lactose lower sulfide liberation. On the other hand, cysteine hydrochloride, sodium cyanide, sodium sulfite, and ethyl alcohol favor sulfide liberation. Prolonged heating of milk at high temperatures produced further changes in sulfide liberation, which is associated with a caramel flavor and a brown color. High heat treatment, particularly under pressure, produced appreciable increases in titratable acidity and destruction of a considerable portion of the lactose. This destruction is favored by the presence of sodium citrate or disodium phosphate. Salts of milk play a significant rôle in the amount of titratable acidity increase. Less than 10% of the acidity was due to lactic acid and 50 to 60% of the heat-

produced acidity was found to be formic acid. This work shows the complexity of the changes occurring in milk at high temperature under various conditions. G.M.T.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

65. The Future of Dry Milk. STEPHEN O'DEA, U. S. Dept. of Agr. Natl. Butter and Cheese Jour., *38,* 1: 80. Jan., 1947.

Increased use of dry milk in some areas through the school lunch program would improve the health of children. Government-owned facilities for producing dehydrated dairy products are located in five states. "It is not feasible to close down the drying facilities and shut off these outlets for farmers' whole milk." Some expansion in U. S. production of nonfat milk solids seems likely. "More thinking needs to be done about the development of markets for nonfat dry milk than for any other manufactured dairy product." W.V.P.

66. The Manufacture and Use of Condensed Cheese Whey and Crude Whey Protein. B. H. WEBB AND C. F. HUFNAGEL, U. S. Dept. of Agr., Washington, D. C. Natl. Butter and Cheese Jour., *37,* 12: 34. Dec., 1946.

Cheese whey can be condensed to 1/10th its volume for 1 to 1.8¢ per lb. of finished product. For human food the whey is pasteurized as soon as it is removed from the cheese. It can be condensed with or without sugar. Unsweetened whey is concentrated to 65–70% total solids. Crystallization of the lactose is controlled by prompt condensing in a clean pan, drawing concentrate as a clear sirup, cooling rapidly at 90° F., seeding with lactose crystals, and stirring. Plain condensed whey with a pH of 4.5 or less can be packed in air-tight barrels and kept for several months at cool temperatures. Sweetened condensed whey (see Jour. Dairy Sci., *21:* 305–314, 1938.) is made by separating, pasteurizing, adding sugar in amounts to equal the weight of whey solids, and condensing to 76% total solids. This concentration at 122° F. gives 1.360 sp. gr. (38.4° Be). The concentrate is cooled to 95° F., seeded, stirred slowly for 1 to 3 hr., and packed in barrels or cans. Refrigerated storage is not required. Whey protein for pharmaceutical uses is separated from whey by heat and acid. The curd is washed with water, drained, pressed, and preserved by drying or freezing. Albumin curd can be dried rapidly at 110–120° F. in a tunnel drier. Some pharmaceutical companies will furnish specifications of purity for albumin powder. The residue can be concentrated for feed or milk sugar. Equipment for sugar manufacture can be supported only by large operations.

Successful commercial uses for condensed whey in food products are

limited at present to confections, bakery goods, and cheese foods. Characteristic flavor and the insolubility of its lactose make whey inferior to skim milk for food purposes. It has high nutritive value and low cost. Formulas are given for whey candy and cookies. Methods of using whey products in bread, sweet baked goods, cheese foods and cream soups are suggested. W.V.P.

67. **A Method for Producing a Dairy Spread.** K. G. WECKEL, Dept. of Dairy Industry, University of Wisconsin, Madison, Wis. Milk Plant Monthly, *35,* 9: 24–25. Sept., 1946.

A method for producing a dairy spread containing 28% butterfat, 19% milk solids-not-fat, with and without added vitamins, is described and illustrated. The ingredients are whole milk powder, cream, buttermilk, lactic acid, salt, vitamins A and D, and starter distillate. After pasteurizing, the spread is homogenized at a pressure which will give the greatest plasticity without graininess (usually varying from 1,500 to 2,500 lbs.). The product is packaged hot, preferably in glass containers of the cottage-cheese jar type. The product sets upon cooling and may be kept 1 or 2 weeks, similar to any soured milk product. G.M.T.

68. **Milk Sugar.** GERTRUDE G. FOELSCH AND HARRY C. TRELOGAN, Production and Marketing Administration, Washington, D. C. Milk Plant Monthly, *35,* 11: 40–41, 48. Nov., 1946.

Renewed interest is being manifest in milk sugar because it is playing an important rôle in penicillin production. A program was inaugurated in 1943 to increase milk sugar production from cheese whey. Manufacturers find partial recovery of crude milk sugar more profitable, using the remaining mother liquor to produce poultry feed. Three grades of commercial milk sugar—crude, technical, and refined—are produced. Emphasis today is being placed on production of the crude form for use in the manufacture of penicillin, although formerly milk sugar was consumed largely in infant foods. G.M.T.

FEEDS AND FEEDING

69. **Vitamin A Requirements in Calves, Part I.** J. M. LEWIS AND L. T. WILSON. New York University College of Medicine, New York City, and The Walker Gordon Laboratories, Plainsboro, N. J. Cert. Milk, *21,* 244: 5. Aug., 1946; Part II, Cert. Milk, *21,* 245: 9. Sept. and Oct., 1946.

Six groups of four calves each were fed various levels of vitamin A, ranging from 32 to 1,024 USP units per kg. of body weight per day. Data were obtained on rate of growth, blood levels of vitamin A, and liver stor-

age. Results indicate that 32 units per kg. of body weight apparently satisfies the minimum requirements. Maximum growth was obtained on an intake of 64 USP units per kg. of body weight. The concentration of vitamin A in the blood was proportional to the intake until 512 units were given, at which level maximal blood concentrations were obtained. In general, liver stores were quite low for calves receiving 32, 64, and 128 units per kg.; moderate amounts of vitamin A were found in the livers of those fed 256 to 512 units, and larger amounts in the group fed 1,024 units. From the standpoint of both growth and liver storage, the daily intake of vitamin A for young calves should be about 250 units per kg. of body weight or 11,000 units per 100 lbs. of liveweight. Thus, the vitamin A requirements in calves are of the same order of magnitude as in young rats and in infants.

W.S.M.

FOOD VALUE OF DAIRY PRODUCTS

70. **Between Meal Milk Drinks Beneficial for Children.** National Dairy Council. Canad. Dairy and Ice Cream Jour., *25*, 11: 78. Nov., 1946.

No adverse effect on the appetite or well being of children ranging in age from 3 to 14 years when fed milk 1 hr. before meals was observed. Tests on 59 children revealed an average stomach-emptying time of 118 min., representing a range of 50 to 170 min. The contributions of two levels of milk (44 and 63 oz.) to the total daily nutrient intake were, respectively: 40 and 49% for calories, 35 and 45% for protein, 85 and 91% for calcium, 30 and 41% for vitamin A, 55 and 65% for thiamine, and 80 and 87% for riboflavin. Each 7 oz. serving of milk contributed approximately 5% of the total caloric intake. H.P.

ICE CREAM

71. **Good Methods of Manufacture for Dry Ice Cream Mix.** S. T. COULTER. Canad. Dairy and Ice Cream Jour., *25*, 11: 61. Nov., 1946.

See Abs. 42, Jour. Dairy Sci., *30*, 2: A20. Feb., 1947.

MILK

72. **Quality Milk from Cow to Milk Plant.** C. B. A. BRYANT, Johnson & Johnson, Chicago, Ill. Milk Plant Monthly, *35*, 12: 26–27, 52–53. Dec., 1946.

Emphasis is placed upon keeping sediment out of milk, as sediment is one of the common causes of milk rejections. Despite care in cleanliness

during the production of milk, sediment gets into milk from loosely covered cans or from nonrinsed cans prior to use. Wind-blown dust is often the cause of sediment in milk. Lids of cans, as well as the can itself, should be protected from dust. Rinse water on the farm may be the source of sediment. Displaying the sediment disc and pointing out the common causes for sediment in milk are aids in keeping the milk clean. The responsibility for clean milk rests not only with the producer but also with the hauler and processor. G.M.T.

73. **Evaluation of Factors when Processing Homogenized Milk.** E. M. GIBERSON. Canad. Dairy and Ice Cream Jour., *25*, 11: 52. Nov., 1946.

Homogenized milk always must be pasteurized, clarified, and processed rapidly and at proper temperatures and pressures. The advantages of homogenized milk are that it produces uniformity of appearance, pouring characteristics, flavor, and color. Before a plant operator purchases equipment and starts processing homogenized milk, he should consider type of pasteurization to be employed, clarification and filtration methods, capacity of various pieces of equipment, and advantages and disadvantages of each. The equipment needed for homogenizing milk requires a considerable capital investment in milk processing equipment.

74. **Flavors in Milk Influenced by Pastures and Cattle Feeds.** JACK BAILEY. Canad. Dairy and Ice Cream Jour., *25*, 11: 59. Nov., 1946.

The problem of preventing the flavors of feed from getting into the milk depends on the time of feeding. It is generally agreed that feed flavor is no longer evident in the milk 5 hr. after feeding. The cows should be kept in an atmosphere free from undesirable odors before milking. If the flavor is due to silage or barn feeds, it is advisable to feed after milking. If the flavor is due to pasture weeds or feeds, it would seem best to bring the cows off the offending pastures preferably 5 hr. and at least 2 hr. before milking. The development of a cowy, old, stale, and then rancid flavor in milk is due to lipase action. This activity is aggravated by shaking whole warm raw milk and by milking cows in advanced stages of lactation. The mixing of milk likely to become rancid with four or more parts of normal milk always will prevent rancidity. In pasteurized milk, oxidized flavor may be caused by absence of bacteria. Metallic, fishy, oily, and tallowy flavors, which are common in pasteurized milk, are caused by dissolved oxygen, copper contamination, oxidase enzyme, and exposure of milk to direct sunlight. H.P.

75. Control of Milk Watering. PAUL CORASH, Dept. of Health, New York, N. Y. Milk Plant Monthly, *35*, 10: 90, 92–93, 96. Oct., 1946.

A study of the detection of milk watering by means of the Hortvet cryoscope, an instrument essentially adaptable to laboratory use but chosen for field use, indicated a relatively large percentage of the samples of producers' milk examined had been watered. The lactometer was used to screen out suspicious cases. Calculating the solids-not-fat content of milk furnished the basis also for judging whether or not a sample of milk should be tested with the cryoscope. Importance is placed on securing relatively fresh samples in order to secure correct cryoscope values. Other methods, such as the copper-serum method and the chemical determination of fat, total solids, and ash on deck samples, also may be used in determining watering, but are considered less accurate than the cryoscope method.

G.M.T.

MISCELLANEOUS

76. Vacreation of Cream, Milk, and Ice Cream Mix and Condensing Milk with the Vacreator. G. H. WILSTER, Oregon State College, Corvallis, Ore. Milk Plant Monthly, *35*, 11: 28–32. Nov., 1946.

The vacreator is illustrated and the steps involved in its operation are described fully, the process consisting briefly in heating the milk product to approximately 200° F. and passing it through a series of chambers with increasing vacua until the product is removed at a markedly lower temperature. The process removes gases and off-odors present in the product; consequently the finished product will be free of off-odors. Butter manufactured from cream by the evacuation process had a higher score than that not treated. Ice cream of an excellent quality was produced from vacreated ice cream mix with which vacreated condensed milk was used.

G.M.T.

77. Recent Developments in Dairy Manufacturing Through Research. G. H. WILSTER. Canad. Dairy and Ice Cream Jour., *25*, 9: 34; 10: 54. Sept. and Oct., 1946.

Some of the recent developments in dairy manufacturing based on research are: (1) the continuous high-temperature short-time pasteurization of milk in a totally enclosed apparatus using clarification, homogenization, and an enclosed cooler; (2) single service containers for milk; (3) sterilized cream; (4) sterilized milk; (5) the use of the vacreator in the dairy industry; (6) metal churn for buttermaking; (7) dry butterfat or butteroil; (8) continuous butter churns; (9) curing cheese in valve-vented cans; (10) packaging rindless cheese in moisture-proof sheets; (11) Army cheese

spread; (12) dry ice cream mix; (13) dry whole milk; (14) dry cream mix for whipping by aeration; (15) sweetened dry nonfat milk solids; (16) frozen concentrated milk; (17) use of cheese whey for candy, soups, puddings, plastics, penicillin; and (18) dairy spreads. H.P.

78. **Flocculation and Sterilization Without the Use of Chemicals.** W. R. MARSHALL. Canad. Dairy and Ice Cream Jour., *25,* 10: 27. Oct., 1946.

Water can be purified and sterilized in any flow-rate gravity or pressure system by the use of aluminum electrodes as a flocculator and silver as a sterilizer. The flocculating unit operates on a D.C. current of 6 volts, 3 amperes, which supplies the current for the flocculating electrodes. Unlike ordinary sand filters which depend on chemicals alone to produce the floc, the system is not affected by the lower temperature of the water. Immediate sterilization is obtained since the coagulant produced by the aluminum electrode holds the silver in an ionized form, immediately attracting and destroying bacteria. The amount of silver ions needed to sterilize water is in the neighborhood of one part in ten million. With this apparatus, which consists of a sand filter tank with rapid flocculators to remove the dirt and the silver electrode to destroy the bacteria, use of any chemicals is not necessary. H.P.

79. **The Use and Abuse of Wetting Agents as Applied to the Cleaning of Milking Machines.** HARLOW L. PENDLETON, Massachusetts Department of Agriculture. Milk Plant Monthly, *35,* 12: 30–32, 70, 72. Dec., 1946.

Experimental data indicated that the flush washing of milking machines using wetting agents was as effective in reducing bacteria counts of milking machine units as brush washing. Also, the cold water prerinsing of milking machines could be eliminated for all practical purposes. After 7 days' treatment, low counts were obtained on milking machines, with no appreciable increase after 14 days. Milkstone deposits were insignificant at the end of 7 days. The flush-washing method of cleaning milking machines, employing wetting agents, was not advocated as a cure-all for cleaning. The process should be used with caution by the careless milk producer. However, the careful operator can clean the machine units with less time and labor when using this method than by brush washing. Until more is known of various detergents and cleaning qualities of wetting agent compounds, intermittent use of brush washing of milking machines must be recommended. Carefully selected detergents with wetting properties, intelligently used, should prove a great boon to the dairy farmer.

G.M.T.

80. Labor-saving Methods and Materials for Dairy Plant Cleaning. D. H. JACOBSEN, Cherry-Burrell Corporation, Chicago, Ill. Milk Plant Monthly, *35*, 11: 24–27, 36. Nov., 1946.

Advancements in machinery design and building materials and layouts make imperative higher standards of plant sanitation despite higher labor costs. Choice of products for cleaning in milk processing plants often is made on bases of wetting properties, water-softening powers, costs, and availability. Properties desired in a good cleaner are: (1) quick and complete solubility, (2) non-corrosive on metal surfaces, (3) complete water-softening or water-conditioning power, (4) good wetting or penetrating action, (5) emulsifying action on fat, (6) dissolving action on milk solids, (7) deflocculating, dispersing, or suspending action, (8) good rinsing properties, (9) germicidal action, (10) economy in use. Straight alkalies, acids, or wetting agents alone do not meet the requirements of a good cleaner. Likewise, a universal cleaner does not exist, since it is not practical to use one cleaning agent on all jobs. Hardness of water plays an important rôle in the efficiency of the cleaner. Phosphates improve the action of all dairy cleaners in hard water. Wetting agents are generally the most expensive component of dairy cleaners. Proper lighting, adequate ventilation, use of pipe wash tanks, storage racks, plant layouts, and machines influence the speed and effectiveness of cleaning. Circulating cleaning solutions and spray systems offer promise in reducing hand labor in dairy plants. Both acid- and alkaline-type circulating cleaning solutions are used in enclosed systems, such as plate heat exchange systems. Spray systems have decided advantage in dairy plant cleaning for large tanks or vats and surface coolers. Portable cleaning units offer a possibility in facilitating cleaning operations. G.M.T.

81. Cleaning Electrical Windings. D. L. GIBSON, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Natl. Butter and Cheese Jour., *38*, 1: 40. Jan., 1947.

Methods of cleaning motors are varied to suit the type of cleaning job required, *i.e.*, removal of grease, softening of varnish for rewinding, removal of effects of exposure to chemicals or flood waters. Standard methods of cleaning include rubbing with lintless cloths soaked in selected petroleum distillates or carbon tetrachloride, use of vacuum cleaning apparatus, spraying or immersing in solvents, and washing with water. It is not advocated that facilities be kept available for such diverse methods, but rather that the job of cleaning be analyzed carefully to save money, time, and labor.

W.V.P.

82. Determination of Refrigerant Pipe Size. H. M. HENDRICKSON, Preston Construction Co., Division of Safeway Stores, Oakland, Calif. Refrig. Engin., *52*, 4: 317–325. Oct., 1946.

The author emphasizes that pressure drop, and not velocity, is normally the governing factor to be employed in sizing refrigerant piping. The chief consideration of refrigerant velocities is to keep them low enough to eliminate excessive noise in the lines, and not so low as to interfere with proper oil return. The author presents tables and charts for the more common refrigerants, with the greatest emphasis on the two most popular (Freon 12 and ammonia) giving the best available information on pressure drop to facilitate the determination of the proper size of refrigerant mains.

L.M.D.

83. Motor Transport Refrigeration. Part I—A Modern Refrigerating Unit. HENRY O. KIRKPATRICK, Advance Manufacturing, Inc., Detroit, Mich. Refrig. Engin., *52*, 6: 521–524. Dec., 1946.

The modern trend in truck refrigeration is toward the self-contained or package-type unit, comprising a compact installation of gasoline engine with starter, compressor, condenser, and receiver fastened on a rigid frame. Above the frame is an insulated platfrom upon which is located the evaporator, heat exchanger, expansion valve, and oscillating fan. The lower portion is closed from the truck body with an insulated bulkhead. Access to the lower compartment of the unit is had by two doors in the front wall of the trunk through which minor service can be rendered or control valves operated. Major servicing can be done from the interior by removal of the bulkhead. Replacement is readily made with a new unit if shop tear-down is required. In this modern unit provision is made to use the reverse cycle employing the refrigerating unit as a heat pump, the evaporator functioning as a condenser and the condenser as the evaporator. This versatility enables the operator to maintain a truck temperature of 0° F. against 80° F. outside or to maintain a temperature of 68° F. inside against that of – 15° F. outside if protection of that sort is needed. The frame installation of the mechanical components of the unit overcomes the road vibration encountered in truck transportation. To protect against excess pressures during shut down, hand valves (six in case of the reverse cycle unit) all are closed completely, isolating the compressor from the rest of the system. Automatic regulation of suction pressure to 30 psi prevents overload during pull-down of truck body temperature from 100° F. to 35° F. design temperature. Another trend will be that of units of 3 to 5 ton refrigeration capacity, capable of maintaining – 10° F. with 3 in. insulation, instead of the present 1 to 2 ton units used to maintain 32° F. with 3 in. insulation or 10° F. in trucks insulated with 6 in. of insulation. This is because the larger capacity

unit takes up little more loading space and together with 3 in. insulation weighs much less than the smaller unit with 6 in. insulation. Also, there is a much greater gain in pay load space, resulting in a lower operating cost per ton hauled. L.M.D.

84. The Use of Silica Aerogel as a Thermal Insulation. F. FAXON OGDEN AND JOHN F. WHITE, Monsanto Chemical Co., Merrimac Division. Refrig. Engin., *53*, 5: 411–414. Nov., 1946.

Silica aerogel is a light, free flowing, voluminous solid having a density of about 7.0 lbs. per cu. ft., approximately 94% of its volume being air. It has a k factor about 10% less than the theoretical value for still air. This is explained on the basis of the pore diameter in the aerogel being about 250 Ångstroms, which is less than the mean free path of the molecules in free air. This causes a reduction in the molecular movement of the air enclosed in the pore spaces and lowers the conductivity of that air below normal. For a mean temperature of 0° F., k is given as 0.13 and for −50° F., as 0.115. Moisture-vapor imperviousness is practically 100% for silica aerogel, but it must be protected against liquid water, for when over 15% by weight is absorbed, the aerogel structure collapses and cannot be restored to its original state. Equilibrium in natural settling is reached after about 5 hr. Mechanical vibration will hasten settling, and by this means speed up in filling cabinet spaces may be obtained. When silica aerogel is subjected to mechanical load, there is initially a relatively large decrease in volume due to closer packing of the individual particles. This is not recovered upon release of pressure. Fire hazard is nonexistent because the material for insulation is heat-treated to remove 7 to 10% volatile matter of inflammable nature. This material is not silicotic, but a respirator mask is advised because of the dust. Because its k factor is about one-half that of materials used for freezer cabinet insulation, a great increase in volume of storage space may be realized without increasing external dimensions, while in the ordinary refrigerator an increase in capacity of between 80 and 90% may be realized. When used in normal spaces designed for other insulating materials, the low conductivity of silica aerogel reduces refrigeration unit operation 40 to 50%. Research is being continued and has already resulted in a product of 3.5 to 4.0 lbs. per cu. ft., retaining all the favorable properties of the original aerogel. L.M.D.

85. Swedish Insulant Offers Useful Properties. THORE M. ELFVING, Stockholm, Sweden. Refrig. Engin., *52*, 4: 311–313. Oct., 1946.

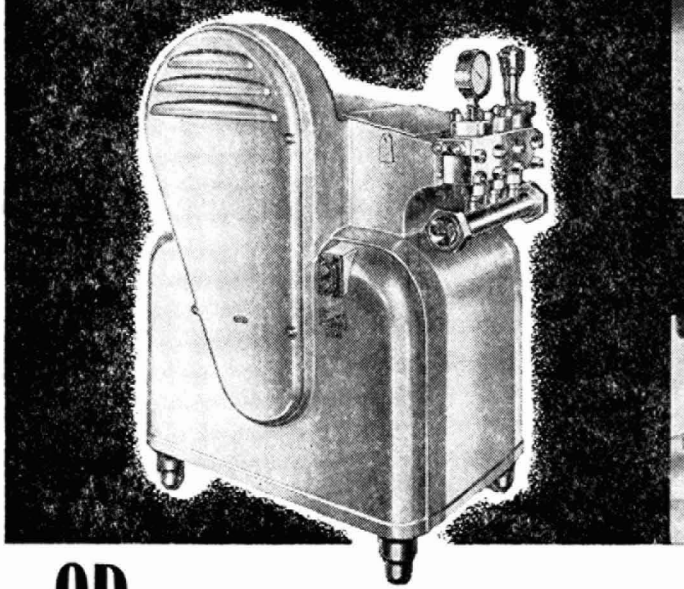
Details are given of the physical properties of Isoflex, a thermal insulant of air layer type made from thin corrugated foils of cellulose acetate. The foils have a thickness of approximately 0.0015 in. These thin foils are

joined with their corrugations at right angles, making a punctiform contact between them. The several foils are joined into slabs of varying thicknesses without adhesive material, being "welded" together by fusing the cellulose acetate at the points of contact. The slabs are 24 in. by 24 in. In order to impart black body property to the cellulose acetate foil, which is much thinner than 0.004 in., an opacifier is added to the cellulose acetate before forming into the foil sheets. This insulant is very light, weighing only 0.67 to 0.8 lb. per cu. ft. It can be cut readily to fit into irregular spaces.

In applying Isoflex, the only requirement is that the slabs fit tightly. The insulating layer should be slightly thicker than the space allowed for it, so that the slabs are compressed slightly. Its flexibility lends it admirably to the insulation of tank trucks for transportation of vegetable oils, milk, and other goods. The thermal conductivity of Isoflex is not given.

L.M.D.

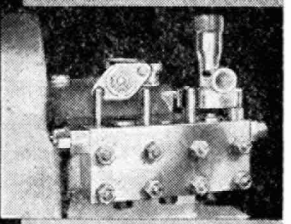
YOU'LL LIKE IT, TOO
for MILK or MIX



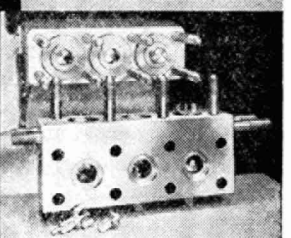
CP Multi-Flo HOMOGENIZER

Whether you are homogenizing milk or mix, you'll find the CP Multi-Flo a dependable performer that saves you both time and money in many ways. All parts are designed and built to provide maximum sanitation. Ability to operate at low pressures cuts power costs. An outstanding economy feature of the CP Multi-Flo is its unique head construction (see panel at right) which simplifies assembly or disassembly time to from 5 to 9 minutes—saving many minutes of clean-up time. Write for Bulletin N-12.

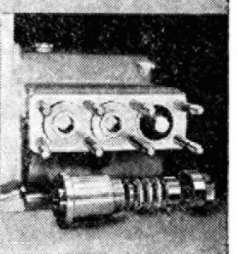
CP MULTI-FLO HEAD EASILY ASSEMBLED OR DISASSEMBLED IN 5 TO 9 MINUTES



View of head partially disassembled, showing sanitary diaphragm type of construction, details of valve seat, and three suction inlet passages.



View of valve block removed and turned around to face the camera. Note the appearance of the front of the cylinders, in position ready to be slipped forward and out.



A close-up of the front of the main pump frame with one cylinder removed and dismantled to illustrate details of cylinder disassembly.

60th ANNIVERSARY 1887 1947

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