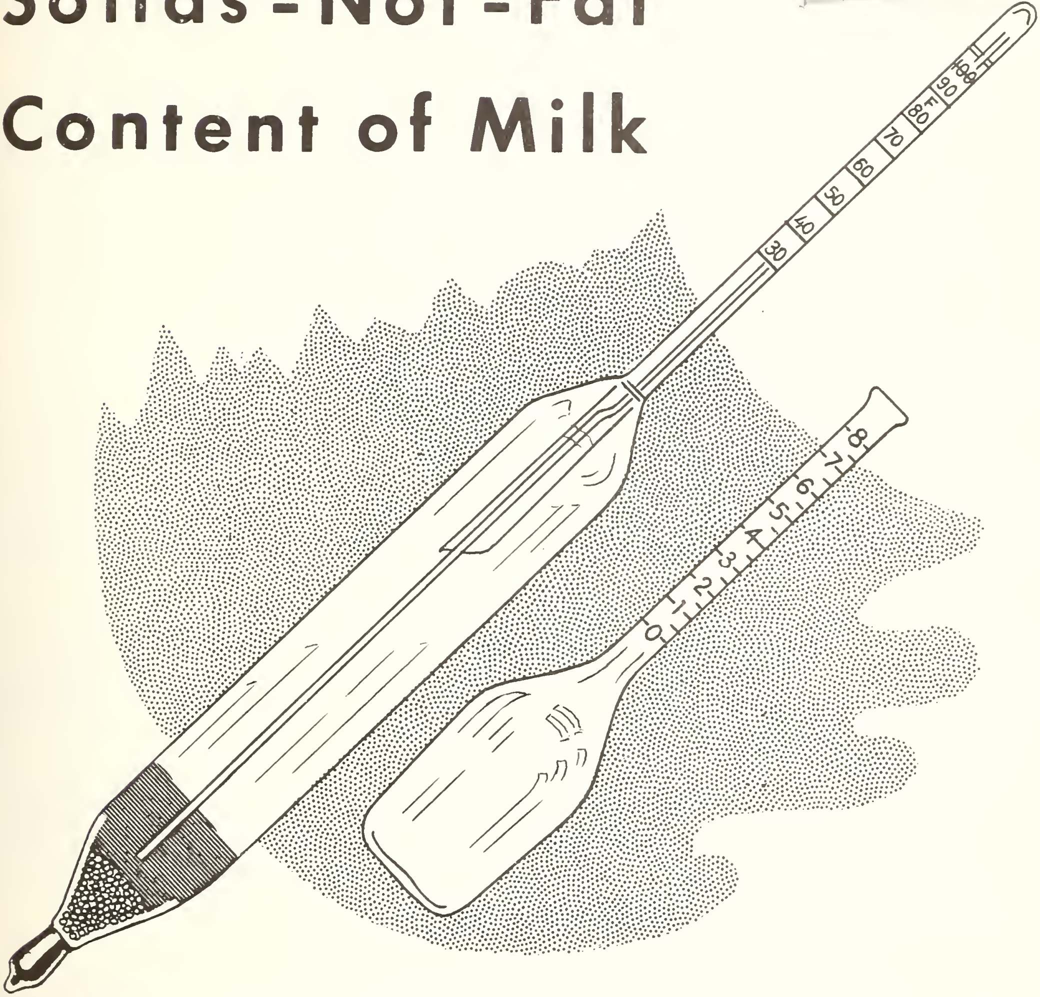
Estimating the Solids-Not-Fat Content of Milk



Marketing Research Report No. 65

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
Washington, D. C.
May 1954

SUMMARY AND CONCLUSIONS

This study on which this report is based was made to measure the accuracy, under commercial conditions, of several commonly used methods of estimating the solids-not-fat content of milk. The average percentage of solids-not-fat content of milk delivered by individual producers at 16 midwestern and western milk-processing plants was estimated from the fat percentage with a standard error of estimate of 0.29. When specific gravity was included in the estimating equation the standard error of estimate was reduced to 0.20. The equations used were:

$$\underline{N} = 7.01 + 0.434\,\underline{F}$$

and

$$\underline{N} = 0.307 + 0.219\,\underline{F} + 0.237\,\underline{L}$$

where $\underline{N}$ is percentage of solids-not-fat, $\underline{F}$ is percentage of fat, and $\underline{L}$ is specific gravity in lactometer degrees.

The equation for estimating solids-not-fat from fat alone is in practical agreement with those of Jack et al., Heinemann et al., and Jacobson. The equations based on fat and lactometer readings agree most closely with the Babcock formula and Ystgaard's modification of the Sharp and Hart formula.

The accuracy of estimating solids-not-fat content of milk at a given plant was greater when equations derived from a study of relationships at the same plant were used than it was when equations based on the observations at all 16 of the plants were used.

A Pearl-Reed growth curve or separate linear regressions for different parts of the range of butterfat tests gave closer estimates of the percentage of solids-not-fat than did the linear regression, but the differences were small and not of practical importance, when the greater convenience of the single linear equation is considered.

The average composition of the 2,752 samples of milk was 3.98 ± 0.63 percent butterfat, 12.71 ± 0.95 percent total solids, with specific gravity 1.03191 ± 0.00108.

The study on which this report is based was conducted under authority of the Agricultural Marketing Act of 1946 (RMA, Title II).

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 10 cents

ESTIMATING THE SOLIDS-NOT-FAT CONTENT OF MILK

By Louis F. Herrmann, Elsie D. Anderson, and Frank A. Bele

INTRODUCTION

A growing knowledge of the nutritional values of milk has resulted in greater emphasis being placed on the solids-not-fat content of milk. Any increase in the proportion of the value of milk attributed to its solids-not-fat content is certain to increase the interest in methods of measuring or estimating the percentages of solids-not-fat in milk. This is especially true in light of recurring proposals that producers be paid for milk on the basis of its solids-not-fat content (5, 13). 1/

Research has established the fact that a fairly close relationship exists between the fat content and the solids-not-fat content of milk (6, 9, 10). In samples of the mixed milk from a herd of cows the solids-not-fat percentage may be estimated from the fat percentage with a standard error of 0.33 to 0.44 (6, 9). By taking into account the specific gravity of the milk, the accuracy of the estimate of solids-not-fat is increased, resulting in a standard error of estimate of 0.17 to 0.24 (6, 14).

The principal purpose of this study was to test the accuracy of the Jacobson equation relating the solids-not-fat to the fat of milk, and of the Babcock formula relating solids-not-fat to fat and specific gravity. These are the most widely known and used of the various formulas and equations of both types, but there had been no previous comprehensive study of their validity under commercial conditions. A secondary purpose was to obtain data on the average solids-not-fat content of milk in some important dairy areas in the United States.

EXPERIMENTAL PROCEDURE

The data analyzed in this study were obtained in visits of 2 to 5 days duration at each of 16 milk-processing plants. 2/ The plants were located in Wisconsin, Minnesota, Idaho, California, Oregon, and Washington. All the plants were engaged in making nonfat dry milk; the data for this report were obtained in conjunction with a study of the yield of milk powder obtained from a unit quantity of milk. Visits to the plants were made between January and July 1950, with the exception of one plant, which was visited in November 1950.

1/ Underscored numbers in parentheses refer to Literature Cited, p. 9.

2/ For the purpose of this report, a receiving station at which samples were taken was considered a part of the plant to which the milk was usually shipped for processing.

Samples were taken from the milk delivered by individual producers. The samples usually were taken from all the producers whose milk came to the plant on one or two trucks, and their milk was sampled on 2 consecutive days. Occasionally, samples were taken from milk delivered by producers selected because they were known to deliver milk with low or high butterfat content. This was done in order to obtain larger numbers of samples at high and low butterfat tests than would be obtained from a random selection of producers.

Samples were taken from the weigh tank with only the degree of agitation resulting from the design of the tanks in use at the respective plants. A 1-pint sample was taken from each producer. For the study of fat and solids-not-fat content in milk of individual producers, daily tests were made. The regular Babcock test was used for fat, and the Mojonnier test was used for total solids.

After the quantities of milk needed for the Babcock and Mojonnier tests had been measured out, the sample bottles were placed in a water bath at 57° to 61° F. until the sample was tempered. The milk was then poured slowly down the side of a glass cylinder, of about 200-milliliter capacity, which was held slightly inclined to minimize bubbles and foam. Sufficient milk was used so that the lactometer—a standard Quevenne—could be read without looking through the cylinder. The lactometer was allowed to float in the milk for 1 minute, before reading, to allow it to come to temperature equilibrium. The reading was made at the top of the meniscus, using a reading glass (2x). The temperature of the milk was then taken with a thermometer, and the reading was adjusted by adding 0.1 for each degree above 60°, or by subtracting 0.1 for each degree under 60°.

At one plant, lactometer readings were made on a number of samples after the samples had been warmed to 90° in a water bath.

The data were coded and punched into cards for the statistical analysis. A scatter diagram was plotted for a sample of the data to observe any fat and solids-not-fat relationship that might thus be evident.

RESULTS OF TESTS

Estimating Solids-Not-Fat From Fat

Solids-not-fat percentage in milk increased an average of 0.43 percent for each increase of one in the fat percentage, according to the equation: $N = 7.01 + 0.434\ F.$ 3/ The standard error of estimate was 0.29. That is, one would expect the estimated solids-not-fat content of two-thirds of samples similarly selected to differ not more than 0.29 percent from the solids-not-fat percentages determined by drying.

The overall result is in practical agreement with the comparable regressions reported by Jack et al. (9), Heinemann et al. (6), and Jacobson (10).

3/ Appendix table 1.

Assuming that the standard errors of the regression statistics of their equations were the same as those found in this study, the differences between the equation reported in this publication and that of Jack et al. could be due to chance. On the same assumption, the regressions of Heinemann et al. and of Jacobson were significantly lower statistically than those found in this study.

Regression coefficients for individual milk-processing plants showed significant differences. The more obvious sources of the differences among equations for the plants in this study were season and breed of cattle, and possibly location. In five of the plants statistically significant differences were found among daily averages of percentages of fat and total solids, lactometer readings, and daily regression coefficients, so that it could not be said that the producers whose milk was sampled each day, or each pair of days, constituted a random sample of producers at the five plants. The results from these plants, therefore, may differ from results at other plants because of the nonhomogeneous nature of the sample of producers.

The variation about the regression for any one plant generally was less than the variation about the over-all regression. This was to be expected, since the full range of factors influencing the regression, such as season and breed of cattle, did not occur at all plants. Standard errors of estimates from the equations for 6 plants were from 0.22 to 0.24 percent, and in only 4 plants was the standard error of estimate from the plant regression larger than that for the general regression. (The estimates from the plant regression for each of these 4 plants, of course, would come closer to the percentages shown by analysis than would estimates from the general regression. The larger standard errors indicate the presence of more unexplained variation in the composition of milk at these plants than at others.)

The rate at which the percentage of solids-not-fat content of milk increased with the percentage of fat tended to be less for the plants at which the average percentage of butterfat was high than for those plants at which the average fat content was low. For example, at plant 13, an average fat test of 4.56 percent was accompanied by an increase of 0.17 in the percentage of solids-not-fat, for each percent of fat. At plant 9, an average fat test of 3.69 percent was accompanied by an increase of 0.50 in the percentage of solids-not-fat for each percent of fat. This result is in accord with findings of Jack et al. (9) and Overman et al. (15) that solids-not-fat increased more rapidly with fat percentages among Holstein-Friesian cows than among Jerseys and Guernseys.

Seasonal factors, as well as varying proportions of the different breeds of cattle, may account for the variation of the regressions among milk-processing plants, as suggested by previous research (8). The data obtained in this study do not permit measuring the variation attributable to seasonal influences.

Estimating Solids-Not-Fat from Fat and Specific Gravity

When lactometer readings were included with percentage of fat as an additional factor for estimating the percentage of solids-not-fat in milk, the over-all standard error of estimate was reduced to 0.20, as compared with 0.29 for estimates from fat alone. 4/ The equation used was:

$$N = 0.307 + 0.219 F + 0.237 L$$

The calculated values for milk of 3-, 4-, and 5-percent fat are 8.29, 8.70, and 9.08, respectively, assuming lactometer values of 30.9, 31.7, and 32.4 (8, p. 9). These are almost identical with values computed from the Babcock formula (2), and the Ystgaard modification of Sharp and Hart's formula (21), but they are lower than values computed from other leading formulas, including those of Richmond et al. (17), Fleischmann (4), other modifications of Sharp and Hart (7, 12, 18), and Heinemann et al. (6). The differences range from 0.1 to 0.3 in percentage of solids-not-fat in milk containing 3-percent fat, and 0.2 to 0.4 for 5-percent milk.

As in equations based on fat alone, equations for single visits based on fat and lactometer readings generally gave greater precision than did the over-all equation. Standard errors of estimate were as low as 0.12 to 0.16 for one-third of the plants. For several plants, the addition of specific gravity to the equation reduced the standard error of estimate to from 55 to 60 percent of that based on fat alone. On the other hand, at two plants the addition of specific gravity to the equation reduced the standard error of estimate by only about one-fifth.

Whether measurements of specific gravity improve the estimate of solids-not-fat appreciably may be influenced by the method of lactometry. Under the method used in this study, lactometer readings would average somewhat lower than the "terminal" values. 5/ In most instances, the milk from the morning milking would not have been cooled long enough for the butterfat to solidify completely. Furthermore, the extent to which the contraction of the fat globules had been completed would vary from sample to sample. This would influence the results, even though morning and night milkings were mixed before the samples were taken.

There were 318 samples for which specific gravity was measured at both 60° and 90° F. The standard errors of estimate of regression equations based on each set of lactometer readings were 0.16 and 0.17, respectively. There is no particular reason to expect lactometer readings at 90° to be less variable than those at 60°, and this is confirmed by the results.

4/ Appendix table 2.

5/ The specific gravity of milk drawn from the cow and cooled immediately to 60° is relatively low, and increases for 12 to 24 hours. The "terminal" value is the specific gravity attained when the rise has stopped.

Paul D. Watson 6/ of the Bureau of Dairy Industry has developed a method of lactometry at 102° F. which has given much greater precision than was attained with readings at 60° or 90°. Lactometer readings at 102° F. for 36 samples of milk from mixed herds (mostly 8 to 15 cows) resulted in an equation relating solids-not-fat content of milk to fat and specific gravity with a standard error of estimate of 0.06. Both the lactometry and the measurements of total solids made by the Bureau of Dairy Industry were probably carried out with greater precision than would be attained in a commercial laboratory. The standard error of estimate of 0.06 is based on only 36 samples and probably is lower than would be obtained with a larger number of samples. Nevertheless, the results give promise of a substantial improvement in the accuracy with which solids-not-fat content of milk can be calculated under commercial conditions.

Solids-not-fat percentages based on both the over-all simple and multiple regression equations were calculated for all the samples at two milk-processing plants, 190 in all. The differences between the calculated percentages and those determined by analysis, grouped by size, are presented in figure 1. The figure emphasizes the greater concentration of small differences resulting from the use of the second type of equation in which solids-not-fat are related to both fat percentages and lactometer degrees.

The samples used were from the two milk-processing plants whose individual plant regression coefficients (0.503 and 0.622) differed more from the over-all linear regression coefficient (0.434) than did those of any of the other plants. For this reason it would be expected that the over-all regression would poorly fit the data at these two plants. Yet the proportion of differences within one standard error of estimate was greater, rather than less, than the 68.3 percent that would be expected by chance. The proportion of samples falling within 2 standard errors was about as expected, whereas the proportion exceeding 3 standard errors was larger than expected.

Linearity of Relationships

To learn whether the Pearl-Reed growth curve—an elongated S—might represent the data better than a linear function, a part of the data was fitted with the equation: $1/T = a - bc^F$. The data was taken from 1,813 out of the 2,752 sets of observations that were available. The curve was fitted to the averages of all total solids observations at each butterfat test, excluding those for tests above 5.30 percent and those in which the butterfat test was recorded in 0.05 percent. The curved regression gave an estimate of total solids which led to a solids-not-fat percentage that was 0.05 lower for milk containing 2.70-percent butterfat, rising to 0.04 higher for milk at 3.90-percent butterfat, and falling to 0.11 lower for milk at 5.30-percent butterfat when compared with estimates from the

---

6/ Calculated from unpublished data of the Bureau of Dairy Industry.

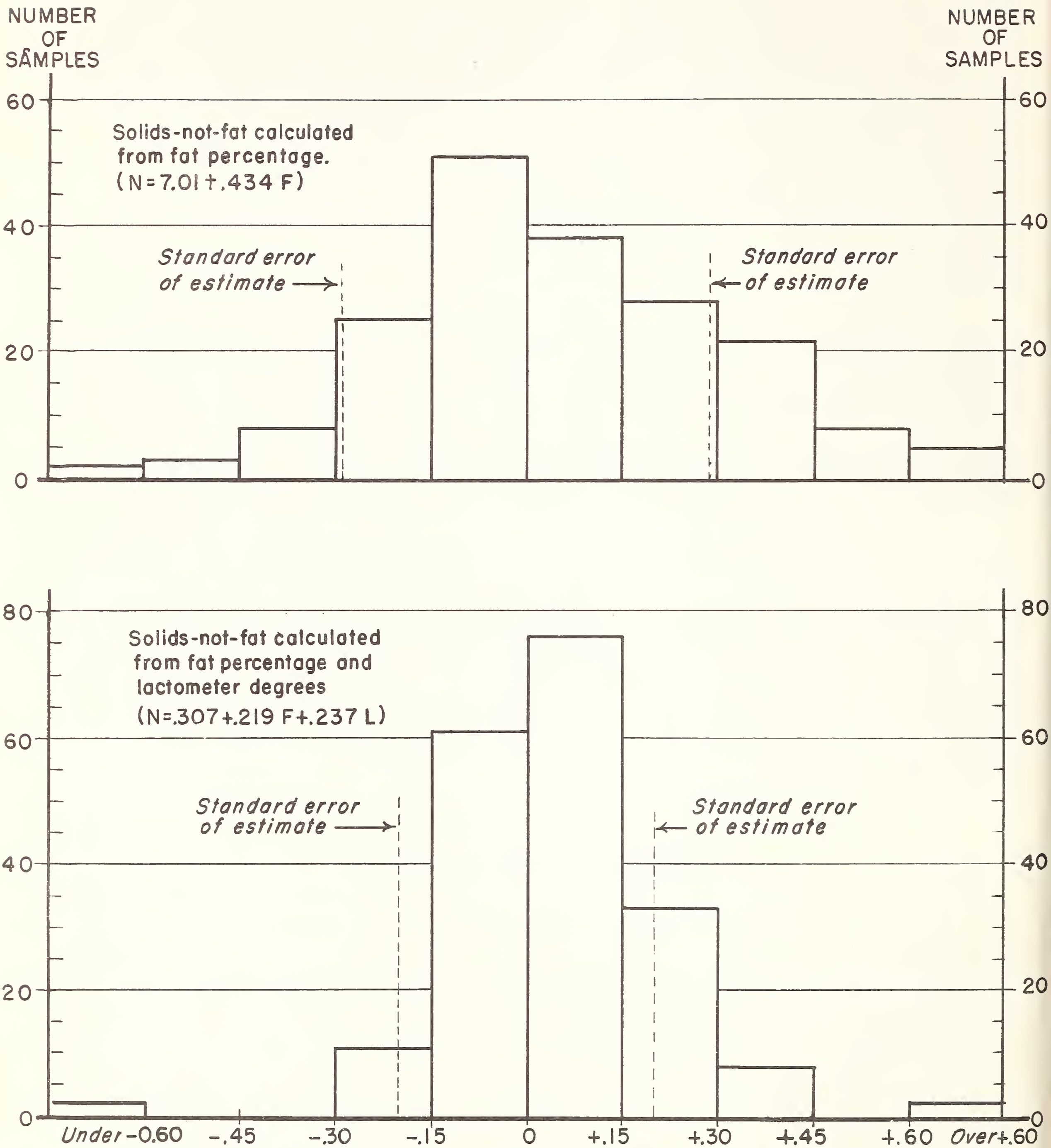


Figure 1.—Differences are shown between the percentages of solids-not-fat content of milk calculated from each of two types of equations and those determined by analysis, using 190 samples.

linear equation. 7/

For another test of whether the linear equation was adequate, the data were sorted into 3 classes according to the percentage of butterfat. The range of butterfat in the lowest class was from 2.70 to 3.80 percent, corresponding roughly to the range of fat percentages of milk from herds of Holstein cows. In this range, solids-not-fat percentages increased 0.372 for each 1 percent increase in fat percentage. 8/ In an intermediate range of 3.85-to 4.70-percent butterfat, the solids-not-fat percentage increased 0.370. Above 4.70-percent butterfat, corresponding roughly to the range of butterfat percentages for Jersey cows, solids-not-fat percentage increased 0.262 with each 1 percent increase in butterfat. These equations when plotted show a step-like pattern. Estimates based on them were closer to the actual solids-not-fat percentages than were estimates based on the over-all equation. The improvement was not statistically significant in samples containing up to 3.80-percent butterfat, but it was statistically significant on the samples containing more than 3.80-percent butterfat. In each instance, the standard error of estimate was altered very little. The improvements in precision, although significant statistically, were not important practically. In other words the gain from using either a more complex equation or a set of linear equations would for most purposes not be great enough to offset the added inconvenience.

Average Composition of Milk

The average butterfat content of the milk sampled at the 16 milk-processing plants was 3.98 percent. 9/ This compares closely with the average butterfat content of milk produced in the United States, which was 3.93 in 1952 (20). The standard deviation of butterfat percentages was 0.63. Milk at different plants averaged from 3.61 to 4.56 percent in butterfat content.

The total solids content of all samples averaged 12.71 percent; the solids-not-fat content was 8.73 percent. There are no estimates of the annual average solids-not-fat content of milk produced in the United States. The solids-not-fat value for the 16 plants was within 0.1 of that to be expected from the fat percentage according to five investigators. The percentage differed by 0.3 from one and 0.6 from another, as follows:

Investigator	Solids-not-fat Percent
Anderson et al. (1)	9.00
Heinemann et al. (6)	8.79
Jack et al. (9)	8.84
Jacobson (10)	8.66
Kahlenberg and Voris (11)	9.31
Provan (16)	8.78
Tocher (19)	8.80

7/ The equation was: $1/\underline{T} = 0.0514 + 0.0409\ (0.968\ \underline{F})$ where $\underline{T}$ is percentage of total solids, and $\underline{F}$ is tenths of 1 percent of butterfat in excess of 2.70 percent.

8/ Appendix table 1.

9/ Appendix table 3.

The value of 8.73 for solids-not-fat percentage is about 0.03 to 0.04 higher than would be expected from the composition of milk supplies of 8 cities of the United States as reported by Dahlberg et al. (3).

These comparisons indicate the extent to which the data may be considered representative of milk produced in the United States. The sampling procedure was not random in that not every milk-processing plant in the United States had an equal chance of being chosen. The incomplete representation of the effect of seasons further limits the extent to which the findings may be generalized.

The standard deviation of the percentage of total solids was 0.95. The range among plants was from 12.16 to 13.61 percent. The highest total solids and the highest butterfat percentages were at the same plant, but the plant having the lowest total solids had the third lowest butterfat content.

The average specific gravity, as would be expected, differed little from plant to plant. The average in Quevenne lactometer degrees was 31.9. The standard deviation was 1.08, and the range of plant averages was from 31.0 to 32.6.

LITERATURE CITED

(1) Anderson, A. C., Langmack, P., and Winther, J. E.
1931. The Composition and Heat of Combustion of Danish Cow's Milk. Proceedings World's Dairy Congress, 1931. Sec. 2. 173-183.

(2) Babcock, S. M.
1897. The Constitution of Milk With Special Reference to Cheese Production. Wis. Agr. Expt. Sta. Bull. 61.

(3) Dahlberg, A. C., Adams, H. S., and Held, M. E.
1953. Sanitary Milk Control and Its Relation to the Sanitary, Nutritive and Other Qualities of Milk. Natl. Res. Council Pub. No. 250. Washington.

(4) Fleischmann, W.
1885. Beitrage Zur Kenntnis des Wesens der Milch. J. Landw. 33: 251-269.

(5) Froker, R. K., and Hardin, C. M.
1942. Paying Producers for Fat and Solids-not-fat in Milk. Wis. Agr. Expt. Sta. Res. Bull. 143.

(6) Heinemann, B., Jack, E. L., Willingham, J. J., Cosimini, J., and Zakariasen, B. M.
1949. Methods of Determining the Percent Total Solids in Milk by Means of the Lactometer. Report of Committee of Amer. Dairy Sci. Assoc. 10 pp.

(7) Herrington, B. L.
1946. The Calculation of Total Solids by Means of the Sharp and Hart Equation. Jour. of Dairy Sci. 29: 87.

(8) Herrmann, Louis F.
1954. Indirect Estimates of the Solids-not-fat Content of Milk. Unnumbered Report. AMS, U. S. Dept. Agr.

(9) Jack, E. L., Roessler, E. B., Abbott, F. H., and Irwin, A. W.
1951. Relationship of Solids-not-fat to Fat in California Milk. Calif. Agr. Expt. Sta. Bull. 726.

(10) Jacobson, M. S.
1936. Butterfat and Total Solids in New England Farmers' Milk as Delivered to Processing Plants. Jour. Dairy Sci. 19: 171-176.

(11) Kahlenberg, O. J., and Voris, L.
1931. The Percentage of Fat as a Basis for Estimating the Composition of Milk. Jour. Agr. Res. 43: 749-755.

300621 O - 54 - 2

(12) Livak, C. W.
1944. Calculating Total Solids in Milk. Nat'l Butter and Cheese Jour. 35: 13-15.

(13) Misner, E. G.
1943. Some Methods of Computing Butter Price Differentials. Cornell Agr. Expt. Sta. Dept. Agr. Bur. Agr. Econ. A. E. Bull. 459.

(14) Overman, O. R., Davidson, F. A., and Sanmann, F. P.
1925. Relation of Solids in Milk to Fat and Specific Gravity of the Milk. Ill. Agr. Expt. Sta. Bull. 263.

(15) Overman, O. R., Garrett, O. F., Wright, K. E., and Sanmann, F. P.
1939. Composition of Milk of Brown Swiss Cows, With Summary of Data on the Composition of Milk from Cows of Other Dairy Breeds. Idaho Agr. Expt. Sta. Bull.

(16) Provan, L.
1949. Investigations into the Composition of Milk. International Dairy Cong. Vol. II, pp. 217-226.

(17) Richmond, H. D., Elsdon, G. D., and Walker, G. H.
1942. Richmond's Dairy Chemistry. Ed. Also, Ed. 1, 1899; Ed. 2, 1914; Ed. 3, 1920.

(18) Rueda, L. L.
1943. An Easy Method for Determining Total Solids in Milk. Milk Dealer. 32: 24-25.

(19) Tocher, J. F.
1925. Variations in the Composition of Milk. (His Majesty's Stationery office. Edinburgh.) 195 pp.

(20) U. S. Department of Agriculture.
1953. Farm Production, Disposition and Income from Milk 1951-52. Bur. Agr. Econ.

(21) Ystgaard, O. M., Homeyer, P. G., and Bird, E. W.
1951. Determination of Total Solids in Normal and Watered Milks by Lactometric Methods. Jour. Dairy Sci. 34: 689-694.

APPENDIX

Table 1.--Regression equations for estimating percentages of solids-not-fat (N) content of milk from percentages of butterfat (F) for each plant, and for samples within specified ranges of butterfat tests

Equation: $N = a + b F$

Plant no. and range of butterfat test	Number of samples	$a \pm \sigma_a$ 1/	$b \pm \sigma_b$	Standard error of estimate	Coefficient of correlation of N and F 2/
1	193	6.812 ± 0.023	0.446 ± 0.032	0.31	0.711
2	95	6.600 ± .027	.503 ± .044	.26	.766
3	95	6.299 ± .027	.622 ± .054	.27	.766
4	225	7.039 ± .021	.398 ± .033	.31	.632
5	50	6.805 ± .031	.478 ± .066	.22	.725
6	327	7.036 ± .013	.455 ± .025	.24	.706
7	172	7.006 ± .025	.411 ± .044	.33	.581
8	167	7.219 ± .017	.410 ± .038	.22	.642
9	318	6.626 ± .015	.500 ± .022	.27	.786
10	247	7.416 ± .018	.350 ± .033	.28	.565
11	154	6.887 ± .018	.484 ± .031	.23	.789
12	156	7.962 ± .024	.212 ± .048	.30	.334
13	155	8.302 ± .023	.166 ± .050	.28	.261
14	194	7.493 ± .016	.329 ± .034	.23	.573
15	156	7.164 ± .019	.394 ± .034	.23	.686
16	48	7.197 ± .039	.408 ± .056	.27	.734
All samples	2,752	7.009 ± .006	.434 ± .009	.29	.684
Range of butterfat tests					
I: 2.70-3.80	1,315	7.197 ± .008	.372 ± .035	.30	.280
II: 3.85-4.70	1,085	7.327 ± .009	.370 ± .034	.28	.315
III: 4.75-7.00	352	7.845 ± .015	.262 ± .041	.28	.326

1/ The symbol σ, used here and in table 2, means the standard error of the specified coefficient. Its numerical values are the limits within which two thirds of the coefficients from repeated studies would be expected to fall.

2/ All the correlation coefficients are significant at the 1 percent level.

Table 2.--Regression equations for estimating percentages of solids-not-fat (N) content of milk from percentages of butterfat (F) and lactometer reading (L) for each plant and for samples within specified ranges of butterfat tests

Equation: $N = a + bF + cL$

Plant no. and range of butterfat test	$a \pm \sigma_a$	$b \pm \sigma_b$	$c \pm \sigma_c$	Standard error of estimate
1	− 0.358 ± .015	0.263 ± 0.025	0.250 ± 0.016	0.21
2	− .485 ± .016	.141 ± .040	.269 ± .022	.16
3	+ .604 ± .018	.266 ± .047	.222 ± .020	.17
4	− .331 ± .014	.167 ± .027	.260 ± .017	.22
5	+ .996 ± .022	.168 ± .065	.220 ± .033	.15
6	+ .174 ± .010	.183 ± .026	.246 ± .016	.19
7	− 1.031 ± .015	.141 ± .032	.288 ± .017	.20
8	+ .101 ± .010	.123 ± .027	.255 ± .014	.12
9	+ .372 ± .009	.305 ± .016	.225 ± .010	.16
10	− .350 ± .011	.119 ± .022	.270 ± .013	.17
11	+ 1.071 ± .014	.302 ± .028	.200 ± .018	.17
12	+ 1.733 ± .017	.066 ± .036	.212 ± .017	.21
13	+ 2.264 ± .019	.115 ± .042	.194 ± .025	.24
14	+ 1.050 ± .009	.170 ± .021	.222 ± .011	.13
15	+ 1.151 ± .011	.217 ± .023	.211 ± .013	.14
16	− .369 ± .027	.190 ± .050	.268 ± .039	.19
All samples	+ .307 ± .004	.219 ± .007	.237 ± .004	.20
Range of butterfat tests				
I: 2.70-3.80	+ .273 ± .005	.087 ± .022	.252 ± .005	.18
II: 3.85-4.70	+ .566 ± .006	.185 ± .025	.234 ± .007	.20
III: 4.75-7.00	+ 1.412 ± .012	.280 ± .032	.194 ± .013	.22

Table 3.—Average percentages of butterfat, total solids, and specific gravity of milk delivered by producers during specified months at 16 milk-processing plants, by States, 1950

State	Plant no.	Month delivered	Number of samples	Average: Butterfat test (F)	Average: Total solids (T)	Average: Specific gravity (L)	Standard deviations: F	Standard deviations: T	Standard deviations: L
				Percent	Percent	Lactometer degrees			
Wis.	1	January	193	3.93	12.50	31.56	0.71	1.07	1.06
	2	do.	95	4.20	12.92	32.02	.61	.95	1.11
	3	do.	95	3.78	12.42	31.74	.51	.86	1.21
	4	February	225	3.77	12.32	31.67	.64	.95	1.03
	5	do.	50	3.77	12.38	31.68	.47	.72	.94
	6	Feb.-Mar.	327	4.11	13.01	32.42	.53	.81	.87
	7	February	172	3.97	12.61	31.69	.56	.86	1.03
Minn.	8	March	167	3.63	12.33	32.03	.44	.66	.86
	9	November	318	3.69	12.16	30.97	.67	1.04	1.10
Idaho	10	May-July	247	3.98	12.80	32.13	.55	.79	.95
Calif.	11	May	154	3.98	12.79	32.62	.60	.92	.93
	12	June	156	3.61	12.34	31.94	.50	.68	1.06
Oreg.	13	do.	155	4.56	13.61	32.25	.46	.60	.77
	14	do.	194	4.43	13.38	32.26	.48	.67	.90
Wash.	15	do.	156	4.27	13.11	32.01	.56	.81	.99
	16	July	48	3.94	12.74	31.47	.69	1.01	.89
All plants			2,752	3.98	12.71	31.91	.63	.95	1.08

U. S. GOVERNMENT PRINTING OFFICE: O—1954