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Agricultural Experiment Station Technical Bulletins | SDSU Agricultural Experiment Station

1978

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Contents



Published in accordance with an Act passed in 1881 by the 14th Legislative Assembly, Dakota Territory, establishing the Dakota Agricultural College and with the Act of re-organization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University. File: 4.6--1,000 printed at estimated 44¢ each--6-78mb--2351A.

# Seasonal and Regional Differences in the Composition of Cows' Milk in South Dakota

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The composition of cows' milk, including both the fat and solids-not-fat (SNF) content, is known to vary over rather broad ranges. Breed and individuality of the cow are the major factors influencing this, but many other factors are also known to exert their influence.

However, it has generally been observed that compensation or complementing occurs when the milk of cows is mixed together, so that the composition of milk from a herd will tend toward averages or norms. This effect is even more marked as the milk from two or more herds is commingled.

Payment for milk on the basis of fat content has been the common practice for many decades. When the practice started it was a logical approach, as the principal product made from milk was butter. However, milk currently is used for many other purposes besides buttermaking, so there has been a progressive movement to give consideration to SNF of milk when the price of milk is established.

Very logically the fat and/or SNF content will affect the yield of manufactured dairy products made from a given supply of milk. The Dairy Science Department at South Dakota State University has received reports of lower than average product yields in some dairy plants in the state. Such low product yields have occurred most often during summer months.

Lower product yields result in lower economic returns to the processing plants and eventually and inevitably to the producers as well. Consequently, management and stockholders have become very concerned. Dairy and food science departments in other states of the North Central region have indicated that dairy plants in those states have had similar experiences in that milk composition does not always fit the average values heretofore reported. If this should be true throughout the country, the reliability of the values derived by Jacobson (15) or other workers for the relationship between fat and other milk constituents, which are the basis for computing milk percent SNF from the percent fat in milk, may no longer be valid. Hence there is a definite need for data on composition of milk currently being produced in the United States.

An investigation was conducted to determine in detail the characteristic composition of milk from various parts of South Dakota during the four seasons of the year and at the same time to provide more information which might affirm or refute a need for updating the Jacobson formula (15) and/or other formulas for computing milk SNF content from the milk fat percentage.

## Historical

In reviewing the composition of milk from the various breeds in Canada and the USA, Armstrong (2) concluded that the average composition of milk from each of the major dairy breeds seemed to show increases in both fat and SNF over the period from 1900 to 1957. However, in the last quarter century the per capita consumption of milk fat has decreased markedly in the USA (4) as people have become calorie conscious and animal fats have been purported to cause atherosclerosis. At the same time increasing emphasis has been placed on high milk production per cow. As a result of selective breeding in accordance with these trends, the solids content of milk has decreased. In comparing the results of a 1971 nationwide survey by Wilcox et al (32) on the composition of milk of the principal dairy breeds with the 1945 data of Overman (26) (Table 1), it is evident that there were marked decreases in SNF percentages of the five breeds during that 25-year period.

Hoover et al (11) stated in 1971 that in the preceding 15 years the national average fat content of milk had declined from 3.86% to 3.68%. Schultz (29) in 1974 reported that marked advances in the last 25 years in genetics, physiology, nutrition, and management had resulted in a change in the average milk fat content from 4% in 1950 to 3.65% in 1972. It has recently been estimated that milk produced in the USA contains about 8.5% SNF and 3.2% protein (14). Harding and Royal (7) cited similar average values of 3.69% fat, 8.60% SNF, and 3.25% protein in milk produced in England and Wales during the period 1947 to 1970.

Formulas relating the SNF content of milk to its fat content have been used for nearly a century to compute one value from the other (22). One of the better known formulas for computing SNF content from the fat percentage is based on relationships published in 1936 by Jacobson (15). His values were based on averages from analyses of over 100,000 milk samples and indicated a certain, though not direct, relationship between fat and SNF contents of milk.

In 1961 Nickerson (24) found the fat to SNF correlation values fell within the expected range. However, Labuschagne (18) reported that no reliable relationship between fat and SNF could be found in analyses of 7,500 herd milk, 3,400 bulk milk, and 750 individual milk samples.

Szijarto et al (31) analyzed weekly milk samples from 24 selected dairy plants in Ontario for protein for a period of 12 months. During eight of the months the casein percentage in the milk protein was significantly below the normal historical value. Low casein levels are of special importance to the cheese industry; for unless the milk is standardized to increase the casein content, cheese yields anticipated on the basis of normal casein content will not be achieved.

Hansen et al (8) reported in 1976 no consistent relationship of fat to SNF content in composite milk samples taken monthly for a one-year period from 16 processing plants in eight different regions of North Carolina. Significant regional differences were found in the content of fat; SNF; and vitamins A, $B_1$,

Table 1. Typical composition of milks of the principal dairy breeds.*

| | Fat | | Protein | | SNF | | Total Solids | |
|---|---|---|---|---|---|---|---|---|
| | 1945 | 1971 | 1945 | 1971 | 1945 | 1971 | 1945 | 1971 |
| | % | | | | | | | |
| Jersey | 5.08 | 5.13 | 3.78 | 3.80 | 9.45 | 9.21 | 14.53 | 14.39 |
| Guernsey | 5.05 | 4.87 | 3.90 | 3.62 | 9.60 | 9.01 | 14.65 | 13.94 |
| Brown Swiss | 3.85 | 4.16 | 3.48 | 3.53 | 9.28 | 8.99 | 13.13 | 13.20 |
| Ayrshire | 4.03 | 3.99 | 3.50 | 3.34 | 9.00 | 8.52 | 13.03 | 12.55 |
| Holstein | 3.41 | 3.70 | 3.32 | 3.11 | 8.87 | 8.45 | 12.28 | 12.19 |

* From the data of Overman (26), 1945, and Wilcox, Gaunt, and Farthing (32), 1971.

and $B_2$. Moreover they found seasonal differences in the content of lactose, fat, and vitamins in the milk. The milk protein content, however, did not vary significantly with region or season.

## Materials and Methods

### Sampling

While the primary goal was to determine the characteristic composition of milk produced in South Dakota, it was desired also to find the manner in which certain major factors influenced variations in that composition. In order to measure seasonal effects, samples of milk were collected and analyzed over a 12-month period. Moreover, to get state-wide representation and simultaneously determine whether milk from different locations in the state varied significantly in composition, six dairy plants were chosen to represent, as nearly as possible, the geographical distribution of the major dairy sections of South Dakota. Plants were located as follows: Plants 1 and 2 were from the northeastern area of the state; plant 3, from the east central area; plant 4, from the south-eastern area; plant 5 from the south central area; and plant 6, from the west central area.

Two one-half gallon samples of commingled milk were taken by plant employees in each plant on alternate weeks for 12 months in 1975 and early 1976 (February 1975 to January 1976). These samples were packed in ice in styrofoam insulated containers and shipped to the Dairy Science Department of SDSU at Brookings. After removal from the ice bath the samples were refrigerated at 3.3 C (38F) and analyzed for the major constituents and salts.

### Methods of Analysis

Protein content. The protein fractions were separated by Rowland's method (28) of selective precipitation and analyzed for nitrogen in each fraction by the Kjeldahl method (3). The nitrogen value was multiplied by the factor 6.38 to obtain protein percentage.

Fat content. Fat content was determined using A/S Foss Electric Milko-Tester MK II. Duplicate determinations were run on each sample, and the tester was calibrated by use of the Babcock test (3).

Total solids content. The total solids content was determined by the standard oven-drying method (3) of the Association of Official Analytical Chemists (A.O.A.C.).

Solids-not-fat content. The SNF content was computed as the difference between total solids content and the fat content.

Ash content. The ash content was determined by the A.O.A.C. official method (3).

Lactose content. The original method proposed by Lawrence (19) for the quantitative determination of lactose in milk was modified in the dilution procedure for this work. The modified dilution procedure as used was as follows:

(a) Pipet 25 ml of milk into 250-ml volumetric flask and make up to mark with distilled water. Mix (1:10 dilution).

(b) Pipet 10-ml aliquot from 250-ml flask into 1,000-ml volumetric flask and make up to mark with distilled water. Mix (1:1000 dilution).

Calcium and Magnesium. The quantitative determination of calcium and magnesium in milk was conducted by the method proposed by Ntailianas and Whitney (25) for direct complexometric determination of calcium and magnesium.

Phosphorus content. For the quantitative determination of phosphorus in milk, Morrison's method (21) was modified for use with milk since the original procedure was for determination of lipid phosphorus. The modified procedure was as follows:

(a) Pipet 2 ml of milk into 100-ml volumetric flask, and dilute to volume with distilled water.

(b) Transfer 1-ml aliquot of the sample solution to a 30-ml micro-Kjeldahl flask.

The rest of the procedure was followed strictly as given in the original method.

Citric acid content. A direct determination of citric acid in milk was made with an improved pyridine-acetic anhydride method proposed by Marier and Boulet (20).

Product yields. Dairy plants which provided the milk samples submitted reports of weights of milk processed and product obtained. The yields of product per kilogram of milk processed were calculated from these data. To provide a common denominator for comparison, cheese yield data were converted to the equivalent amount of cheese of 37% moisture content. Actual yields of nonfat dry milk were used.

## Results and Discussion

### Gross Composition of South Dakota Milk

The average composition of milk from six plants in South Dakota during the period February 1975 to January 1976 is shown in Table 2. As is usually true, there was less variation in the composite milks than has been reported (16) to be true of variations in the milks from individual cows. The mean value of the fat content was approximately that of typical Holstein milk (32); which might have been expected, since the predominant breed in South Dakota is Holstein (about 95%). However, the total solids, total protein, and SNF contents of South Dakota milk were lower than the values reported for the average content of Holstein milk in 22 states from a recent U.S.A. survey (32) and in Canadian studies (1). The overall low mean values for total solids, total protein, and SNF contents of South Dakota milk were comparable to low values reported by Herrington et al (10) in 1972 for milk in New York state, where the Holstein breed also predominates.

Table 2. The average composition of milk from six plants in South Dakota during the period February 1975 to January 1976 (274 samples).

| | Mean value | Standard deviation |
|---|---|---|
| Total solids (%) | 12.02 | 0.32 |
| Fat (%) | 3.69 | 0.21 |
| Total protein (%)[a] | 3.09 | 0.13 |
| Lactose (%) | 4.76 | 0.14 |
| Ash (%) | 0.69 | 0.01 |
| SNF (%) | 8.33 | 0.22 |
| Protein fraction | | |
| Casein (%) | 2.31 | 0.11 |
| Whey protein (%) | 0.59 | 0.05 |
| Non-protein nitrogen (%) | 0.03 | ---- |
| Salt constituents | | |
| Calcium (mg/100 ml) | 139.09 | 4.54 |
| Magnesium (mg/100 ml) | 11.02 | 0.84 |
| Phosphorus (mg/100 ml) | 97.21 | 2.72 |
| Citric acid (mg/100 ml) | 192.11 | 9.98 |

[a] Converted on basis of total nitrogen, which would contain approximately 5% non-protein nitrogen. Hence, the true protein value would be 2.90%.

The significance of variations in composition of milk due to season (month) and to area (plant) was measured by least squares analysis of variance. These results are listed in Table 3 and indicate that there were significant (P<.01) compositional differences that occurred in the commercial composite bulk milk samples, both from month to month and among plants. All the constituents which were analyzed throughout a whole year in this survey did vary significantly (P<.01) with month and also showed significant differences among plants.

Total solids. Plant average values for total solids and the several constituents of milk from six plants during the period of February 1975 to January 1976 are shown in Table 4. Average values for each month are shown graphically in Figure 1 and depict the seasonal variations during the year. The average total solids content for all samples tested was 12.02% with fairly high seasonal variations characterized by low total solids values from April to September and high values from October to March.

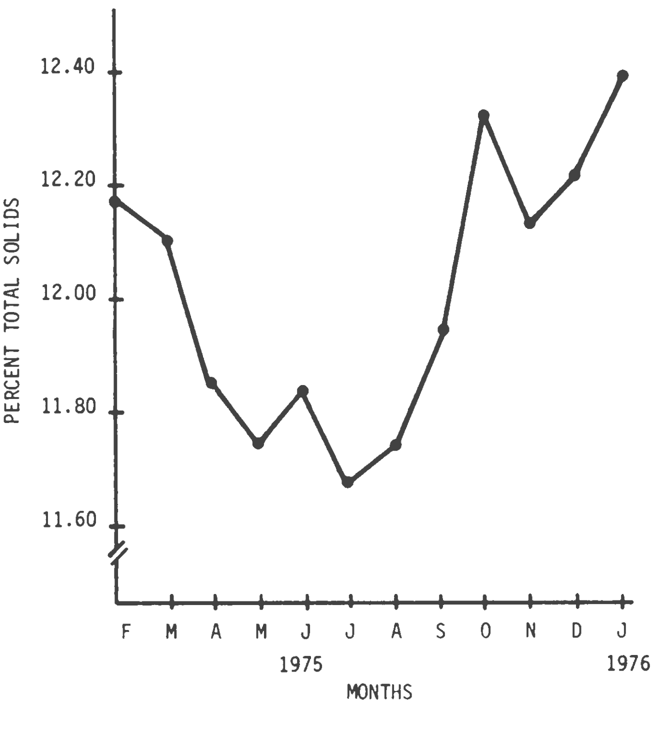


Fig. 1. Monthly values for total solids content of milk from six South Dakota plants during the period February 1975 - January 1976.

Lower than average total solids values were obtained in the milk from plants 1 and 2, and higher than average values were obtained in milk from the other plants (Table 4). Thus, in terms of locality, milk from the northeastern area of the state had significantly lower total solids contents than that from other areas of the state. This area included the county producing more milk than any other county in the state. Evidently, when farmers selected cows to produce more milk, total solids content in the milk was depressed as the gain in production occurred. Such an inverse relationship between solids content of the milk and volume of milk produced per cow usually does occur (27).

Fat. As shown in Figure 2, monthly average values for the fat content of the milk tended to follow the traditional seasonal pattern for fat in areas having summer grazing and stored feed in winter, with the level being higher in late fall and winter and lower in summer. The average fat content of the milk was below 3.5% in only 3 months of the entire year (May, June and July). There were significant differences in the fat content of the South Dakota milk sampled from the respective plants (Table 4), with significantly lower fat percentages in the milk from plants in the northeastern part of the state. The annual average fat content for all the samples tested during this investigation was 3.69%.

Total protein. The average total protein content for all the year's samples was 3.09%. There were marked seasonal changes in total protein content (Figure 3). The protein content was at a relatively high level when the research started in February and then dropped rapidly until the end of May. In June the protein percent increased; then the protein content dropped to a low again in all plants during July and in four plants during August, after which

Table 3. Results of least squares analysis of variance for the compositional variations in milk due to season (month) and to area (plant).

| Variable | Plant | Month | Plant X Month | Remainder |
|---|---|---|---|---|
| | Degrees of freedom | | | |
| | 5 | 11 | 54 | 203 |
| | Mean Square | | | |
| Total solids | 1.2610** | 1.1038** | .0762** | .0247 |
| Fat | .1949** | .6377** | .0259** | .0111 |
| Solids-not-fat | .6785** | .2049** | .0516** | .0214 |
| Total protein | .1777** | .1542** | .0150** | .0044 |
| Casein | .0780** | .1147** | .0142** | .0039 |
| Whey protein | .0153** | .0189** | .0024** | .0007 |
| Lactose | .1483** | .0650** | .0251** | .0138 |
| Ash | .0014** | .0013** | .0001** | .0005 |
| Calcium | 52.5068** | 346.0553** | 9.3067** | 4.5722 |
| Magnesium | 2.2433** | 7.2371** | .8528** | .2763 |
| Citric acid | 513.5706** | 752.1224** | 170.1613** | 33.2174 |
| Phosphorus | 31.9039** | 60.4826** | 9.8843** | 3.0180 |

**Significant (P<.01).

Table 4. The plant average composition of milk in South Dakota during the period February 1975 to January 1976.

| | Plant[1] | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| | (%) | | | | | |
| Total solids | 11.81[c] | 11.78[c] | 12.06[b] | 12.17[a] | 12.02[b] | 12.18[a] |
| Fat | 3.63[c] | 3.60[c] | 3.75[a] | 3.77[a] | 3.67[b,c] | 3.68[b] |
| Total protein | 2.99[c] | 3.02[c] | 3.07[b] | 3.12[a] | 3.14[a] | 3.14[a] |
| Casein | 2.26[c] | 2.25[c] | 2.30[b] | 2.33[a,b] | 2.36[a] | 2.33[a,b] |
| Whey protein | 0.56[c] | 0.59[b] | 0.59[b] | 0.61[a] | 0.59[b] | 0.61[a] |
| SNF | 8.19[d] | 8.18[d] | 8.31[c] | 8.40[b] | 8.36[b,c] | 8.50[a] |
| Lactose | 4.17[c] | 4.70[c] | 4.75[b,c] | 4.78[b] | 4.71[c] | 4.85[a] |
| Ash | 0.69[c] | 0.68[d] | 0.70[a] | 0.70[a] | 0.69[b,c] | 0.70[a] |
| | mg/100 ml | | | | | |
| Calcium | 137.8[b] | 137.1[b] | 139.1[a] | 140.1[a] | 139.2[a] | 139.6[a] |
| Magnesium | 10.9[c] | 10.7[c] | 11.3[a] | 11.1[a,b] | 10.8[c] | 11.2[a,b] |
| Phosphorus | 97.1[b] | 95.5[c] | 97.2[a,b] | 98.2[a] | 96.8[b] | 97.6[a,b] |
| Citric Acid | 190.9[c] | 187.8[c] | 187.8[c] | 196.6[a] | 193.3[b] | 192.8[b] |

[a,b,c]-Plant means with same superscripts in a horizontal row do not differ significantly (P<.01) by Student-Newman-Keul's test (30).

[1] 50,36,48,50,42, and 48 samples, respectively

it slowly rose until the end of the year. Although these were only one year's data, the protein seasonal variation pattern was very similar to the protein seasonal changes pattern reported for Ontario milk (12). Concerning plant differences in total protein content of milk, it can be seen (Table 4) that while the milk from plants 1 and 2 of northeastern South Dakota had significantly lower values, results for milk from plant 4, 5 and 6 of the southeastern, south central, and west central parts of the state were not significantly different from each other.

Casein. The monthly and seasonal values for casein closely followed the values for total protein (Figure 3) in that they fell from January to April then started rising above the average in September and reached a peak in November. The average casein content for milk collected during the entire year was 2.31%.

Plant averages for casein content of milk for the period of sampling (Table 4) indicated that only milk from plants of northeastern South Dakota has casein content significantly lower than that of other plants.

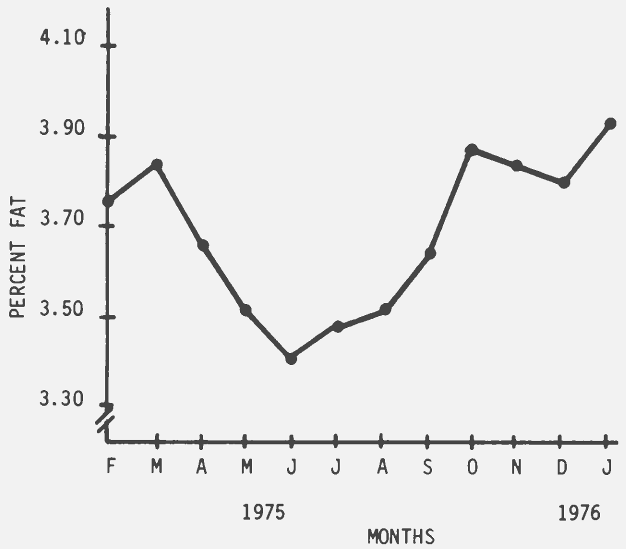


Fig. 2. Monthly values for fat content of milk from six South Dakota plants during the period February 1975 - January 1976.

Whey protein. The average whey protein value for all the year's samples was .59%. Whey protein content was lower than average in February through July; then from August it rose slightly to the end of the year (Figure 3). The data in Table 4 show that the whey protein content of milk from one plant in northeastern part of the state was significantly lower than that from the other areas. The milk from the plants of west central and southeastern areas showed significantly higher whey protein content than the milk received from the other plants.

Solids-not-fat. The combined average monthly milk SNF values are shown graphically in Figure 4, together with percentages of total protein and lactose, which constitute the major portion of SNF in milk. The average SNF for all the year's determinations was 8.33%. In this survey, SNF results below the average were obtained during the periods March to May and July to September, when total protein

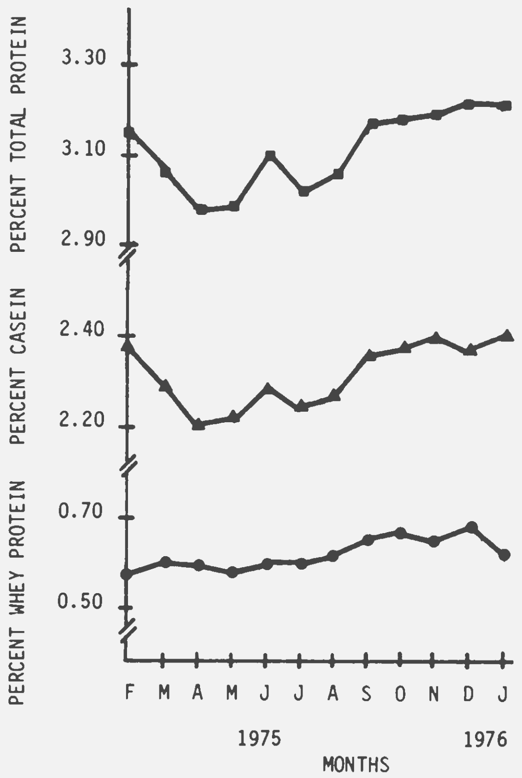


Fig. 3. Monthly values for total protein, casein, and whey protein contents of milk from six South Dakota plants during the period February 1975 - January 1976.

results were also low (Figure 4). Higher SNF values were obtained during the period of October to February.

Just as there were differences in total protein content in South Dakota milk from the various plants (Table 4), similar significantly lower SNF contents occurred in milk from the plants of the north-eastern part of the state. In order to improve returns to both the producers and the processors, more research should be done in this area to study in more detail how management, feeding, or environmental factors can be altered to increase the levels of constituents in the milk in this area.

Lactose. The average lactose content for all samples tested was 4.76%. Small average monthly and plant variations were found for lactose (Table 4 and Figure 4), results being only .08% higher in June and .12% lower in November than the overall average. Even in plants 1 and 2 where low SNF values were found, the lactose contents were only .05 - .06% lower than the overall average. The milk from plant 6, west central South Dakota, was found to be significantly higher in lactose content than the other plants.

Ash. The ash content is generally thought to be one of the most constant factors in the composition of milk. The ash content for all the year's samples tested in this survey showed average plant and monthly variations of less than ± .02% from the average of .69% (Table 4 and Figure 5). Ash content tended to be higher in the early winter months of November, December, and January (Figure 5), but the magnitude of this effect was not great. The data in Table 4 also indicate significantly higher ash content in milk from plant 6 of the west central and plants 3 and 4 of the east central and southeast, whereas the lowest ash content was obtained in milk from plant 2 of the northeastern area.

Calcium. The average total calcium content of all milk samples was 139.1 mg/100 ml, which is similar to the normally reported values (16). The calcium content

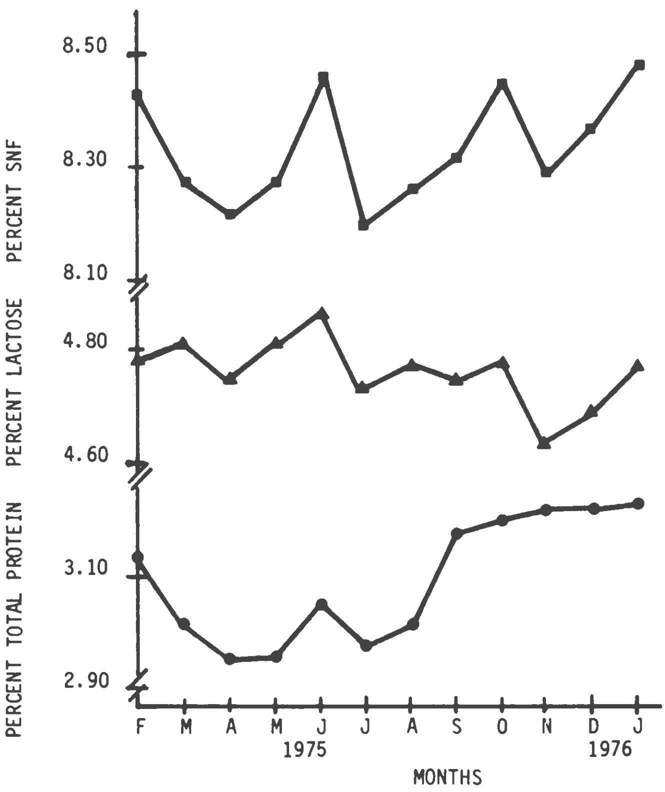


Fig. 4. Monthly values for SNF, lactose, and total protein contents of milk from six South Dakota plants during the period February 1975 - January 1976.

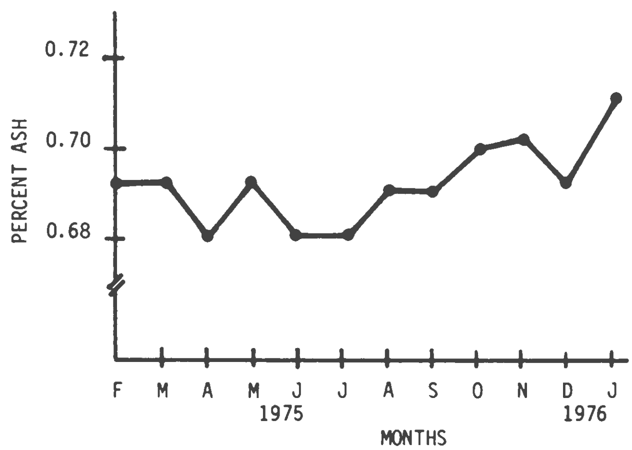


Fig. 5. Monthly values for ash content of milk from six South Dakota plants during the period February 1975 - January 1976.

tended to be significantly lower in the months of March and July and higher in the late fall and winter months of October, November, December and January (Figure 6). As was true with other components, milk from plants of the northeastern part of the state was found to have significantly lower calcium content than the milk from other plants (Table 4).

Magnesium. The average total magnesium content of all samples was 11.0 mg/100 ml, which is in the range of normally accepted values (16). The amount of magnesium was lowest in the winter and reached the highest levels in early spring (Figure 7). During the months that calcium content was high (Figure 6) the magnesium content tended to be low. This inverse relationship between calcium and magnesium contents in milk was also found by Nickerson (23) in California milk. Concerning plant differences (Table 4), milk from plants of the northeastern and south central parts of the state had significantly lower contents of magnesium than that from other plants.

Phosphorus. The average phosphorus content of all milk samples tested was 97.2 mg/100 ml and confirmed generally reported values (16). The phosphorus content declined to a low in late summer months of July and August (Figure 8). A similar seasonal curve pattern also has been reported by Ellenberger et al (6). Tha phosphorus content in the milk from plant 2 of the northeast was significantly lower than that of milk from the other plants.

Citric acid. The citric acid content of all the samples tested in this work averaged 192.1 mg/100 ml, which is in agreement with generally reported values (16). Figure 9 shows that there was no distinct seasonal pattern in the citric acid content of South Dakota milk, which is contradictory to the results reported by Heinemann (9). He found a seasonal variation with a low citric acid content in the early winter months of November, December, and January. For plant differences (Table 4), milks from plants of the northeastern and east central areas of the state had significantly lower citric acid content than that from the other plants.

Casein/fat ratio. In 1966, Kosikowski (17) stated that in order to obtain the best yield and quality of cheddar cheese, the optimum


Fig. 6. Monthly values for calcium content of milk from six South Dakota plants during the period February 1975 - January 1976.

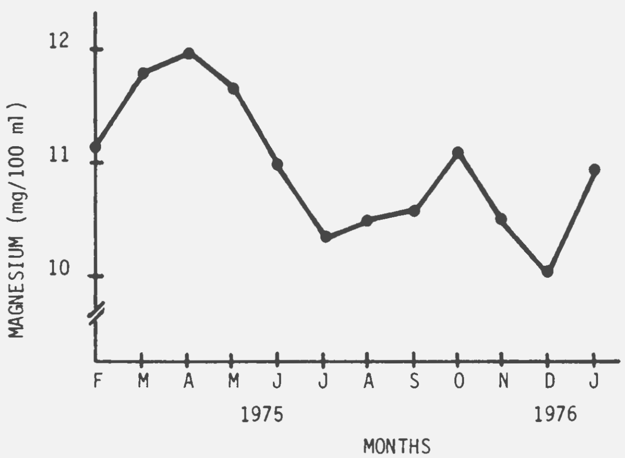


Fig. 7. Monthly values for magnesium content of milk from six South Dakota plants during the period February 1975 - January 1976.

casein/fat ratio in milk should be 0.7 part casein to one part fat. In 1972, Chapman and Burnett (5) also showed an improved grading score for cheese made with milk produced during the grazing period (April to October) and associated this with the increasing amount of casein in relation to fat in the milk.

The average casein/fat ratio from South Dakota milk during the period of February 1975 to January 1976 was .63 with the ratio ranging from .60 in March and April to .67 in July (Table 5). A narrow range of annual average of results (.62 - .64) was shown for all the plants. The desired optimum ratio of 0.7 was never obtained in the milk sampled, which indicated that the South Dakota milk sampled contained too low casein content for each part of fat that existed in the milk from the standpoint of cheddar cheese manufacturing. This would suggest that standardization might be feasible. Information such as given in Table 5 should be very useful for the South Dakota cheese industry to help managers to weigh the factors involved and determine if it is economically profitable to adjust the composition of milk prior to the manufacture of cheese.

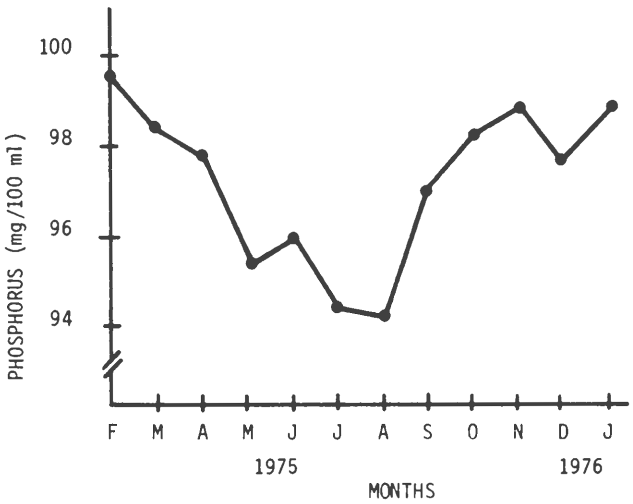


Fig. 8. Monthly values for phosphorus content of milk from six South Dakota plants during the period February 1975 - January 1976.

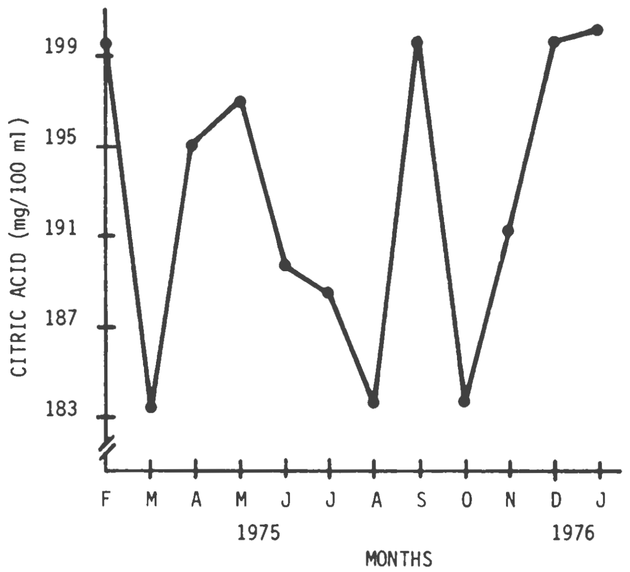


Fig. 9. Monthly values for citric acid content of milk from six South Dakota plants during the period February 1975 - January 1976.

Table 5. Average values for casein/fat ratio of milk from six South Dakota plants during the period February 1975 - January 1976.

| Plant | Total no. of samples | Casein/Fat Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Overall average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | .65 | .61 | .60 | .63 | .67 | .64 | .61 | .64 | .61 | .61 | .63 | .61 | .62 |
| 2 | 36 | .65 | .61 | .63 | .62 | ---- | .62 | .65 | .65 | .63 | .59 | .57 | .63 | .62 |
| 3 | 48 | .63 | .53 | .60 | .62 | .69 | .66 | .65 | .64 | .61 | .62 | .60 | .57 | .62 |
| 4 | 50 | .61 | .59 | .60 | .63 | .66 | .63 | .63 | .61 | .62 | .62 | .62 | .62 | .62 |
| 5 | 42 | .66 | .62 | .61 | .66 | .66 | .66 | .64 | .68 | .64 | .66 | .62 | .62 | .64 |
| 6 | 48 | .61 | .62 | .57 | .66 | .69 | .66 | .68 | .65 | .59 | .63 | .65 | .65 | .63 |
| Overall average | 274 | .63 | .60 | .60 | .63 | .67 | .64 | .64 | .64 | .62 | .62 | .61 | .61 | .63 |

## The Relationship Between Fat and Solids-not-fat, Fat and Total Protein, and Fat and Total Solids in South Dakota Milk.

Several correlations among the constituents of milk have been found (13, 15, 22, 31) and have been used in the dairy industry for many years to support activities or investigations in nutrition, breeding, and/or processing (24) or for regulatory purposes (22). An original purpose of this survey was to provide information to affirm or refute a need for updating the formulas that are used to compute SNF content from fat percentages; but it was found that interrelationships that have been reported for fat and SNF did not exist in the South Dakota milk sampled. From the data in Table 6, it is evident that fat content correlated significantly (P<.01) with total solids and with total protein content of milk. However, the correlation between fat and SNF was not significant at this level in the milk analyzed in this study. The results suggested that SNF content could not be estimated by determining the fat content only. This situation is not peculiar to South Dakota; Herrington et al (10) reported that New York state milk did not show a significant (P<.01) correlation between fat and SNF. Although Armstrong et al (1) analyzed Alberta bulk milk for a 2-year period and found that the correlation between fat and SNF was significant (P<.01), the corresponding results from Manitoba milk which they used for comparison showed no significant (P<.01) correlation between fat and SNF.

Since relationships between fat and SNF were not definite, a regression equation could not be used to estimate one value from the other. However, protein or total solids content in milk might be used for future milk pricing systems, since there was a positive significant (P<.01) correlation between these two values and fat (Table 6). However, more research should be done in South Dakota before a regression equation can be set between protein and fat for future practical purposes.

## The Seasonal Variations of Cheese Yield in Two South Dakota Plants

Monthly cheese yield (i.e. the amount of cheese obtained from a certain amount of milk) data were provided by two plants and were converted to the basis of cheese of 37% moisture content (Figure 10). It was evident that the cheese yields in the plants varied substantially during the course of the year. The greatest yield difference in plant A was about 1 kg of cheese per 100 kg of milk, while the yield at plant B varied nearly 1.5 kg of cheese per 100 kg of milk, between July and December in each plant.

Table 6. Simple correlation coefficients between fat and some selected milk components.

| | Total solids | Total protein | Solids-not-fat |
|---|---|---|---|
| Fat | .736 ** | .497 ** | .177 ns |

** Significant at 1% level

ns Not significant at 1% level

Both plants had lower cheese yields during the months of May, June, July, and August, and higher cheese yields during the months of November, December, and January (Figure 10). It is casein that forms the curd and traps the fat in the manufacture of cheese. Logically, then, the cheese yield should be relatively low or high in direct proportion to the casein content of the milk used in cheese-making. Comparing cheese yield data (Figure 10) with seasonal variation patterns for casein and fat in the milk (Figure 2; and Figure 3), it may be perceived that lower fat and casein content occurred during the same months (May, June, July, and August) when lower cheese yields occurred. In South Dakota the processors still pay for milk on the basis of the fat content; but since casein content definitely will play a very important role in the final cheese yields, it merits consideration in the pricing of milk. As far as milk composition found in this study and maximum cheese yields are concerned, the best time in the year to make cheese is in November, December, and January.

## The Seasonal Variations of Nonfat Dry Milk Yield in Three South Dakota Plants.

The monthly average yields for nonfat dry milk were provided by three plants. There were definite seasonal variations for nonfat dry milk yields in these three plants (Figure 11). The greatest difference between highest yield in November and lowest yield in August was about 1.2 kg of product per 100 kg of milk in plant X. The greatest difference in plant Y was about 0.5 kg product per 100 kg of

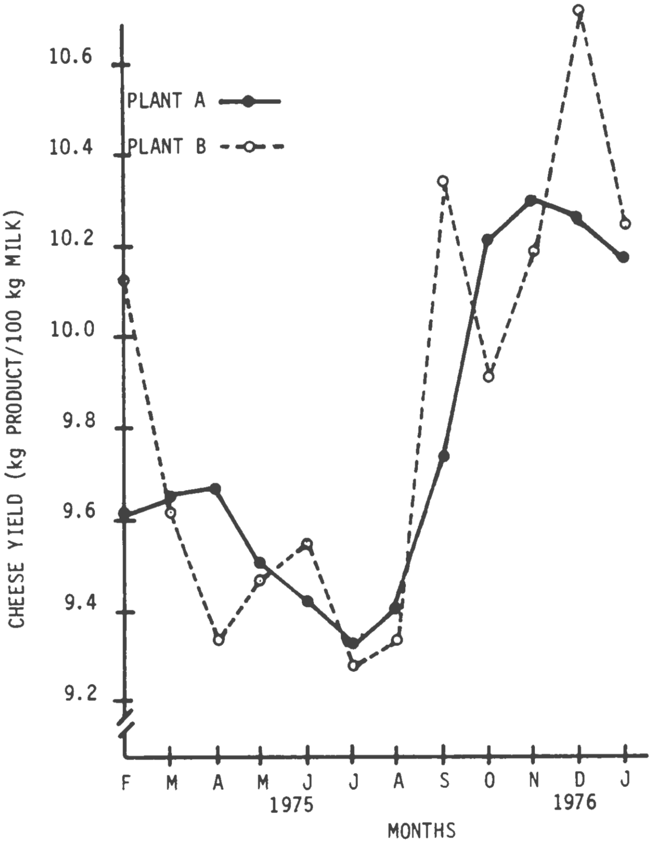


Fig. 10. Monthly values of cheese yields in two South Dakota plants during the period February 1975 - January 1976.

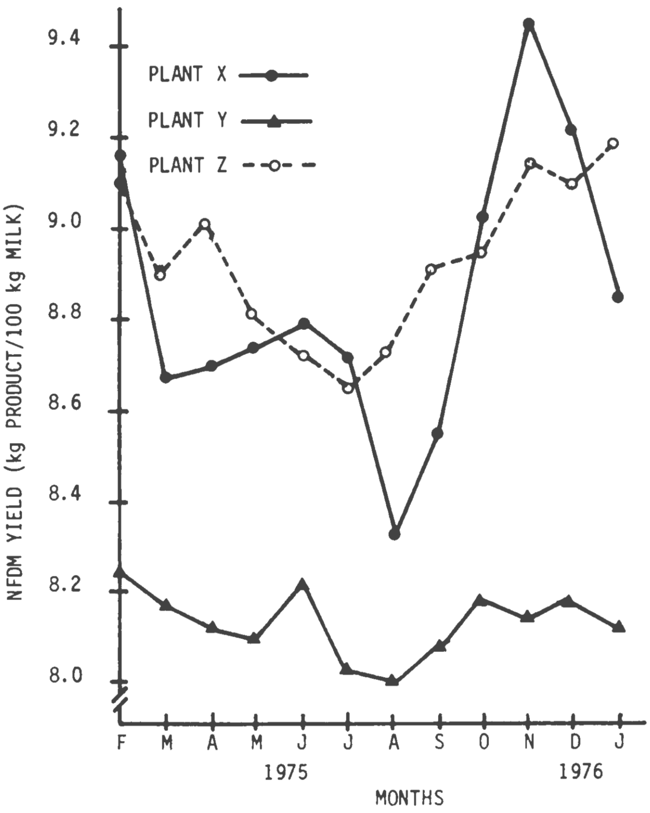


Fig. 11. Monthly values of nonfat dry milk product yields in three South Dakota plants during the period February 1975 - January 1976.

milk. There were only .24 kg product yield difference per 100 kg milk in plant Z between highest yield in February and lowest yield in August. The actual yields of nonfat dry milk product in plant X and Y were higher than that in plant Z, but the overall trends were similar. All three plants had lower yields during the months of July and August, and higher yields in the months of November, December, January, and February, which also correlated with the seasonal levels of SNF content in milk.

## Summary

Biweekly milk samples from six plants in South Dakota were collected from early February 1975 through January 1976. Each sample was analyzed for total protein, casein, whey protein, fat, total solids, lactose, ash, and individual mineral salts of calcium, magnesium, phosphorus, and citric acid.

The yearly average percentage for the main components were as follows: Total solids, 12.02%; fat, 3.69; SNF, 8.33; total protein, 3.08; casein, 2.31; whey protein, .59; lactose, 4.76; and ash, .69. The results for total solids, total protein, and SNF in South Dakota milk were lower than the values reported for average content of Holstein milk in recent USA and Canadian studies.

The content of the components varied significantly ($P<.01$) with season, generally being lowest during the summer months. There also were significant ($P<.01$) differences in the levels of these milk constituents among plants. Milks from the northeastern part of the state had significantly ($P<.01$) lower contents of most constituents.

The monthly average values for casein-to-fat ratio ranged from .60 in March and April to .67 in July. A narrow range of annual average ratios (.62 - .64) was found for all the plants. The desired optimum ratio of .70 for the best yield and quality of cheddar cheese was never obtained in the milks sampled, which indicates that South Dakota milk contained too low casein content for each part fat that existed in the milk from the standpoint of cheddar cheese manufacturing.

Fat content correlated significantly ($P<.01$) with total solids and with total protein content of milk. But no significant ($P<.01$) correlation was obtained between milk fat and SNF content, which suggested that SNF in South Dakota milk varied independently of the fat content; and the SNF content could not be estimated by determining the fat content only.

The monthly cheese yields results provided by two plants in South Dakota during this survey period tended to follow the seasonal trends of fat and casein content in the milk. The nonfat dry milk powder yield results provided by three plants in South Dakota were also correlated with the seasonal level of SNF content in the milk.

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