ABSTRACT

The suitability of California raw milks for the production of cheese was evaluated during 1983 by measuring the distribution of nitrogen in 1417 samples of farm milk from four major dairy regions of California. Both Kjeldahl (431 samples) and the Udy dye-binding procedures (986 samples) were used. True protein concentrations measured by Kjeldahl varied from 2.66 to 4.41% and averaged 3.32%. For samples measured by Udy, true protein concentrations ranged from 2.56 to 3.93% and averaged 3.15%. Casein as a percent of true protein varied from 69.1 to 80.4% and averaged 76.4% for samples analyzed by the Kjeldahl procedure. For samples analyzed by the Udy procedure, casein as percent of true protein ranged from 72.8 to 80.7% and averaged 77.0%. There was close agreement between values obtained by the Udy and Kjeldahl procedures, which suggests that milk can be chosen for cheese production on the basis of its casein content using the Udy procedure.

INTRODUCTION

When milk is used to make cheese, casein is the only protein precipitated. Consequently, the best milk to use for cheese production is that which has the highest casein concentration rather than the highest total protein content. For example, two milks that contain 4 and 3.8% true protein would be equally good for cheese production if they each had the same casein concentration; i.e., if 75 and 79%, respectively, of their total protein was casein.

The proportion of milk protein that is casein in cows' milk depends on the animals' breed, nutritional state, health (particularly with respect to udder infections), and management scheme (6). Holstein cows predominate in California dairy herds, so only the last three factors are important variables.

The purpose of this survey was to determine the concentration and variability of casein in California milk so that a growing cheese industry in California can more accurately predict the costs of cheese production.

MATERIALS AND METHODS

Farm milk samples were collected from farm holding tanks by licensed weighers and samplers using standard methods (13). Samples were obtained once a month for about 12 mo in the four principal dairying areas of California: the Los Angeles (LA) basin, the northwest (NW) coast, the S. San Joaquin Valley, and the North San Francisco Bay Area (North Bay). Samples

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were delivered under refrigeration to cooperating processing plants where they remained refrigerated at 4°C until they were shipped in insulated containers to the University of California, Davis (UCD). Analysis was initiated as soon as samples arrived.

For Kjeldahl analyses, triplicate 1-g milk samples were taken after the samples were prepared as recommended in Standard Methods for Examination of Dairy Products (13). Nonprotein and noncasein fractions were prepared using Rowland’s procedure (14) on samples that were large enough to require about 40 ml of titrant. Digestions were done under conditions recommended in Official Methods of Analysis (16). True protein was calculated as 6.38 times (total nitrogen – nonprotein nitrogen), and casein was calculated as 6.38 times (total nitrogen – noncasein nitrogen). Casein, percent of protein, was calculated as 100 times casein divided by true protein.

For Udy analyses, triplicate 2.3-g milk samples were taken immediately after preparing the samples for Kjeldahl analysis. Noncasein fractions were prepared for Udy analysis by adjusting 100 g of milk at 40°C to pH 4.6, filtering the whey after the casein coagulated, and collecting the whey. Whey protein was measured on triplicate 10-g samples of the whey. The reagent dye concentration and calibration of the colorimeter were checked regularly. All samples were weighed to four significant figures, and protein concentrations of milk and whey were calculated using the March 1974 version of the milk and milk product table of computation formulas (10). Casein concentrations were calculated as the difference between total protein (true protein, since the Udy procedure does not measure nonprotein nitrogen) and whey protein concentrations. Casein, percent of protein, was calculated as 100 times casein divided by true protein.

All statistical analyses were performed using various subroutines of the SPSS software package (12) available on the UCD campus computer.

RESULTS AND DISCUSSION

Our data for casein as a percent of total nitrogen (Table 1) are comparable to values reported by Kindstedt et al. (8), who found an average of 77.5% in 146 Vermont samples they analyzed, and to those reported by Nickerson (11), who found an average of 76.7% in 258 California samples he analyzed. Our values for nonprotein nitrogen as a percent of total nitrogen (Table 1) are comparable to those reported by McDowell (9), who found an average of 6.46% in New Zealand Friesian milk, and to those reported by Nickerson (11), who found an average of 5.76% in milks he examined.

Ashworth (1) and Haenlein et al. (7) found that the proportion of true protein that is casein in milk from healthy cows averaged 77% and that as the number of leucocytes in milk increased, the proportion of casein decreased. Our means for casein as percent of true protein, 76.4% by Kjeldahl and 77.09% by Udy (Table 1), are in good agreement with their results for healthy cows’ milk. However, we found milks in which this proportion was as low as 69.1%
by Kjeldahl and 72.8% by Udy; Ashworth (1) and Haenlein et al. (7) would have considered these values presumptive evidence of mastitis in the herds that produced those milks. In another publication (2), Ashworth et al. reported that although the true protein content of milk from mastitic quarters was not different from that of healthy quarters, the ratio of casein to true protein was lower in milk from mastitic quarters because casein synthesis was depressed and the whey proteins increased in mastitic milk.

Regional differences (Table 2) for all the protein components were statistically significant. Milks produced in the LA basin had the least protein and casein, the lowest casein proportion, and the highest nonprotein proportion, whereas milk produced on the NW coast had the most protein and casein, the highest casein proportion, and the lowest nonprotein proportion.

Nickerson (11) and Bruhn and Franke (5) also reported significant regional differences. At the time of Nickerson's report (11) these differences could be attributed to the fact that many of the milking herds in the North Bay and NW coast were Jersey and Guernsey. Since the late 1970s, almost all the milking herds in California were Holstein; the number of remaining Jersey and Guernsey herds was not sufficient to significantly affect mean protein concentrations in milk. Bruhn and Franke (5) attributed the significant regional differences to differences in dairy management practices between southern and northern California.

In southern California (the warmer, drier part of the state), feeding is largely dry lot and dairying is carried on year-round, with cows freshening in roughly equal numbers during each month of the year. In cooler, more moist northern California it is still possible to provide some natural pasture, or green chop, to dairy cattle. Dairying in the NW coast area is more seasonal with cows freshening mostly in spring. In his review (6), Feagan cites evidence to suggest that both the concentration and composition of protein in cows' milk can be affected by climate and the availability of fresh, lush pasture.

Regional differences in protein distributions are illustrated by frequency distributions (Figures 1 to 7). Protein values (Figure 1) are clustered between 2.9 and 3.6% in the LA basin.

<table>
<thead>
<tr>
<th>Component</th>
<th>Los Angeles basin</th>
<th>North Bay</th>
<th>San Joaquin</th>
<th>Northern coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>True protein</td>
<td>3.35 ± 0.09</td>
<td>3.14 ± 0.29</td>
<td>3.14 ± 0.17</td>
<td>3.24 ± 0.29</td>
</tr>
<tr>
<td>Udy total protein (TP)</td>
<td>3.15 ± 0.17</td>
<td>3.04 ± 0.12</td>
<td>3.08 ± 0.12</td>
<td>3.62 ± 0.10</td>
</tr>
<tr>
<td>Udy casein</td>
<td>2.71 ± 0.21</td>
<td>2.51 ± 0.27</td>
<td>2.61 ± 0.21</td>
<td>2.90 ± 0.27</td>
</tr>
<tr>
<td>Casein, % of TP</td>
<td>76.94 ± 0.79</td>
<td>76.84 ± 0.80</td>
<td>78.27 ± 0.81</td>
<td>78.25 ± 0.94</td>
</tr>
<tr>
<td>Udy casein, % of TN</td>
<td>5.62 ± 0.39</td>
<td>5.70 ± 0.39</td>
<td>5.48 ± 0.39</td>
<td>5.16 ± 0.39</td>
</tr>
<tr>
<td>Nonprotein, % of TN</td>
<td>1.3 ± 0.10</td>
<td>1.1 ± 0.10</td>
<td>1.3 ± 0.10</td>
<td>1.2 ± 0.10</td>
</tr>
</tbody>
</table>

Values on the same line having different superscripts differ significantly at (P<0.05).

Total nitrogen.
Figure 1. Regional frequency distributions of percent true protein in California milks: crosshatched bars, by the Kjeldahl procedure; stippled bars, by the Udy procedure.
Figure 2. Regional frequency distributions of percent casein in California milks: crosshatched bars, by the Kjeldahl procedure; stippled bars, by the Udy procedure.
Figure 3. Regional frequency distributions of casein as a percent of true protein in California milks: cross-hatched bars, by the Kjeldahl procedure; stippled bars, by the Udy procedure.
Figure 4. Regional frequency distributions of nonprotein nitrogen as a percent of total nitrogen in California milks, as measured by the Kjeldahl procedure.
with less than 20% of the observations above 3.3%. The largest group (>30%) of observations on the NW coast is between 3.5 and 3.7% and over 30% are above 3.7%. Frequency distributions of protein components for the other regions are more similar to that of the LA basin than to that of the NW coast.

Casein values (Figure 2) are clustered between 2.5 and 2.7% (Kjeldahl) and 2.3 and 2.5% (Udy) in the North Bay, LA basin, and S. San Joaquin. In the LA basin and the S. San Joaquin, more than 30% of the observations are below 2.5% (Kjeldahl). In the LA basin, more than 30% of the observations are below 2.3% (Udy). In the NW coast, all the observations are above 2.5% (Kjeldahl) and 2.3% (Udy).

Kjeldahl casein proportions (Figure 3) are clustered around 76% in the North Bay, LA basin, and the S. San Joaquin. In the LA basin, 18% of the observations are in the range that Ashworth (1) or Haenlein et al. (7) would consider indicative of mastitic herds. In the NW coast, only 4% of the observations are below 77%.

Udy casein proportions (Figure 3) are clustered around 78% in all four regions. In the North Bay, LA basin, and S. San Joaquin, more than 30% of the observations are below 77%. In the North Bay and LA basin more than 10% of the observations are in the range that Ashworth (1) or Haentein et al. (7) would consider indicative of mastitic herds. In the NW coast, only 20% of the observations are below 77%.

Ashworth's data were collected by measuring the total protein, precipitating the casein at pH 4.6, washing away the whey proteins, and

![Figure 5](image-url)

Figure 5. Changes over time of mean percent true protein, as measured by the Kjeldahl procedure, in California milks from four geographic areas. Standard deviations of means are indicated by vertical bars.

![Figure 6](image-url)

Figure 6. Changes over time of mean percent total protein, as measured by the Udy dye-binding procedure, in California milks from four geographic areas. Standard deviations of means are indicated by vertical bars.
then redissolving and measuring the casein. The data reported here were derived by measuring total protein and the whey protein. Because the dye-binding capacity of whey protein is higher than that of casein, the estimates of casein and casein proportion using this procedure are expected to be low. This underestimation is less than 5% of the measured value, so for assessing the suitability of farm milks for cheese production or the health of a dairy herd, this procedure is acceptable.

Nonprotein nitrogen proportions (Figure 4) are clustered around 5.5% in the North Bay, S. San Joaquin, and LA basin. In these regions, more than 20% of the observations are greater than 5.75%. In the NW coast, more than half of the observations are below 4.75%.

Changes over time in the protein components are displayed in Figures 5 to 11. In this survey, there were no statistically significant time-of-year effects. Other investigators have reported seasonal variations in the gross composition of milk. Nickerson (11) found that total nitrogen and casein nitrogen were higher in November, December, and January. McDowell (9) reported that total nitrogen and true protein nitrogen were higher in March and April in New Zealand, which would correspond to September and October in California. Bruhn and Franke (4) found that protein (measured by infrared analysis) was higher in November, December, and January. Barbano and Sherbon (3) observed that summer milk had less casein than winter milk. Sommerfeldt and Baer (15)

Figure 7. Changes over time of mean percent casein, as measured by the Kjeldahl procedure, in California milks from four geographic areas. Standard deviations of means are indicated by vertical bars.

Figure 8. Changes over time of mean percent casein, as measured by the Udy dye-binding procedure, in California milks from four geographic areas. Standard deviations of means are indicated by vertical bars.
found that milk protein was lower in June, July, and August than during the rest of the year.

CONCLUSION

The survey results (Table 1) show that casein in California farm milks varies from 1.77 to 3.64%. The mean and standard deviation are 2.68 and .30 for Kjeldahl and 2.43 and .21 for Udy measurements. In view of these variations, California plant managers involved in cheese manufacture would be advised to institute a program to monitor the casein content of incoming milk. The Udy procedure is capable of supporting such a program. Conclusions based on results of Udy measurements are in good agreement with those based on results of Kjeldahl measurements, even though the two procedures do not always yield exactly equivalent values for protein or casein concentrations.

The survey results indicate that perhaps as many as 10% of California's dairy herds have significant levels of mastitis. A mastitis-monitoring program could be used to identify these herds so that appropriate treatments could begin. Such a program would benefit both the producer and the processor, because the productivity of these herds and the casein concentration of their milk would be increased.
Figure 11. Changes over time of mean nonprotein nitrogen as percent of total nitrogen, as measured by the Kjeldahl procedure, in California milks from four geographic areas. Standard deviations of means are indicated by vertical bars.

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REFERENCES