

MILK COMPOSITION AND CHEESE YIELD FROM HARD AND SOFT CHEESE MANUFACTURED FROM SHEEP MILK

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Abstract

Hard and soft cheeses were produced from early, mid, and late season sheep milk. Fat recoveries in the cheeses were not affected by milking season while protein recoveries in cheeses from midseason were significantly higher than cheeses from early or late season milk. Cheese yields from early season milk was higher than mid or late season milk and was a result of higher solids in the milk. Recoveries of fat, protein, and solids from this study indicate that the Van-Slyke cheese yield formula can be used for calculating theoretical cheese yields from sheep milk.

Introduction

The U.S. dairy sheep industry is still in the early stages of development. Initial use of sheep milk for cheese manufacture was started in the mid 1980s. The first commercial dairy sheep flocks were established in Wisconsin starting about 15 years ago. In 1996, the University of Wisconsin-Madison accepted the mission of furthering research on dairy sheep production and management. Since then, Dr. David Thomas of the Animal Sciences Department and Yves Berger of the UW-Madison Agricultural Research Stations have been conducting extensive research on the genetics and management systems impacting sheep milk production (1, 2).

Since milk costs are high, it is necessary to review factors influencing milk composition and resulting cheese yield. Fat and casein are the two primary milk components that are recovered in the cheese making process and are directly related to cheese yield. The majority of ovine milk in the United States is produced on a seasonal basis, with lactation running from early spring until fall. Typically, with bovine milk both fat and protein tend to increase throughout the lactation that generally would result in higher cheese yield for late lactation milk (3, 4). In some previous studies on bovine milk (5, 6, 7) researchers have shown no significant increases and, in some cases, possible decreases in yield with late lactation milk. Changes in milk composition and increases in somatic cell counts (SCC) in late lactation milk have resulted in lower levels of casein and decreased cheese yield capacity (7, 8).

The composition of ovine milk during the milking season principally reflects the lactational and nutritional differences (9). In ovine milk, fat concentration increases at a disproportionate level to casein in late lactation so that the casein to fat ratio in the milk

decreases throughout the lactation (10). Several reports of cheese yields for ovine milk have been published (11, 12, 13, 14); however, information on stage of lactation or season was not reported.

Currently, adequate information does not exist to predict cheese yield from ovine milk composition. The objectives of this study were to determine the influence of milking season on fat and nitrogen recoveries in hard and soft cheese, to determine actual and composition adjusted cheese yields from ovine milk, and to develop a predictive cheese yield equation using the Van Slyke model.

Discussion

Impact of Sheep Milk Composition on Cheese Yield

Since milk costs represent over 85% of the cost of producing cheese, it is critical to review factors influencing milk composition and resulting cheese yield. Fat and casein are the two primary milk components that are recovered in the cheese making process and are directly related to cheese yield. It then becomes critical for the manufacturers of sheep milk cheeses to be able to estimate cheese yields from milk of varying composition.

Currently, yield predictability relative to seasonal changes in sheep milk composition is missing. The objectives of this study were to determine the influence of milking season on fat and nitrogen recoveries in a hard pressed cheese and a soft sheep milk cheese and to determine actual and composition adjusted cheese yields from sheep milk. The hard-pressed cheese was similar to Manchego cheese produced from sheep milk in the La Mancha region in Spain. The soft cheese was similar to Camembert, which is a popular soft mold-ripened cheese.

Milk from East Friesian-crossbred, Lacaune-crossbred, and East Friesian-Lacaune-crossbred ewes was obtained at three different stages of the milking season (early, mid and late milking season) from the Agricultural Research Station of the University of Wisconsin-Madison located in Spooner, Wisconsin. Lambs were removed from the ewes 24-36 h post-partum and ewes were milked twice daily (15). Milk was collected from ewes starting at day 4 after lambing. Milk was collected daily from the flock until 909 Kg was obtained for each stage of lactation. Average composition of the pasteurized sheep milk for each portion of the 2002 milking season is shown in Table 1. Total solids, milk fat and total protein decreased as the season progressed. Casein concentration was similar in early and mid-season milk, but lower in late season milk. Early season milk contained a higher percentage of serum proteins as indicated by the lower casein to true protein ratio. The higher fat and protein in early lactation milk was also observed by McKusick et al. (15) when lambs were weaned at day 1 and ewes milked twice daily. The lower levels of fat and protein in early lactation milk reported by Pellegrini et al. (10) were from milk from ewes 48-55 days after lambing. The slightly lower fat and true protein in the August milk varied from the typical lactational trends of higher fat and protein in late lactation ovine milk reported by other workers (9, 10, 16).

This most likely was due to the impact of hotter temperatures during the month of August or poorer pastures resulting in lower solids milk similar to that experienced in bovine milk (17, 18). SCC was not elevated in late lactation milk as previously reported by some researchers (19, 20). Average composition of the pasteurized sheep milk from the 2003 milking season used for the soft cheese production is shown in Table 2.

To accumulate sufficient milk for cheese making, the milk was frozen in covered and sealed polyethylene-lined 13-kg pails at -20°C and stored for less than 2 mo before it was used for cheese manufacturing. Five vats of cheese (136.2 kg of milk) were made from each stage of milking season. Milk was pasteurized at 72°C for 19 s. For the hard-pressed cheese, the milk was cooled down to the ripening temperature, 31°C and a mesophilic DVS culture (F-DVS 850, Chr. Hansen, Inc, Milwaukee, WI) was inoculated into the milk. Cheese was produced through the end of the whey drainage by the procedure as outlined in a previous study (12). For the soft cheese, the milk was cooled down to the ripening temperature, 32°C and a mesophilic DVS culture (CH-N-19, Chr. Hansen, Inc, Milwaukee, WI) was inoculated into the milk. Cheese was produced by the American Style-Camembert procedure outlined by Kosikowski and Mistry (21).

Hard-pressed cheeses from February had higher fat and lower protein than cheeses from May or August milk as shown in Table 3. This was the result of having milk with a lower C/F ratio in the February milk. There was no significant impact of season on moisture of cheeses prior to brining. No significant differences were observed in coagulation rate or in time from set to hooping for the three sources of milk. Time from set to hooping ranged from 150 to 155 minutes. After 2 months of aging and drying, cheeses from February milk were also higher in fat and lower in protein than May and August milk. Soft cheeses from May milk had higher protein than cheeses from January or September milk but had equivalent fat and moisture contents as shown in Table 4.

Milking season had no significant effect on fat retention in either the hard pressed or the soft ripened cheeses produced from sheep milk (Table 5). The soft cheeses have slightly lower fat retention than the hard pressed cheeses. Fat retention in a hard-pressed sheep cheese is considerably lower than the 93% used for the theoretical cheese yield formula for Cheddar cheese (22). Lower fat retention with sheep milk may be due to the higher percentage of smaller fat globules in sheep milk (23) and the structure of the casein network of the curd at cutting. Higher casein milks may produce gels with larger pore size, leading to higher fat loss (24). There was no significant difference in recovery of N in the form of hard-pressed cheese during the milk season. Soft ripened cheese from May milk had a higher retention of N than either January or September milk. The soft cheeses also had a slightly lower N retention than the hard-pressed cheeses. Table 6 shows a comparison of the fat and protein recoveries from our current study with previously reported values for sheep milk cheeses. Pirisi et al. (25) reported fat retentions of 78.0 – 81.4% for an uncooked semi-hard cheese from sheep milk while Economides et al. (11) reported 86.9% fat retention in Halloumi cheese from sheep milk. Gonzalez et al. (26) reported 65% fat retention in La Serena cheese. Soft cheeses, e.g., Camembert and La Serena, showed a lower retention of protein than the lower moisture, firmer cheeses.

Predictive cheese yield formulae were also developed for each trial using the Van Slyke cheese yield equation as shown below:

$$\text{Van Slyke Cheese Yield} = \frac{[(RF \times \% \text{ Fat in milk}) + (RC \times \% \text{ Casein in milk})] \times RS}{(100 - \% \text{ Moisture of cheese})}$$

$$RF = \frac{(\% \text{ fat in cheese} \times \text{cheese wt})}{(\% \text{ fat in milk} \times \text{milk wt})}$$

where *RF* is the fat recovered in cheese, *RC* is the casein recovered in cheese and *RS* represents the other milk solids and added salt recovered in cheese. *RF* values were determined experimentally for each cheese trial by dividing the amount of fat in milk by the amount of fat recovered in cheese (% fat in cheese x cheese weight / % fat in milk x weight of the milk). *RC* can be approximated from milk and cheese composition by dividing total cheese casein (paracasein) by total milk casein. We found that *RC* was 0.96 for early and mid-season milks and 0.94 for late-season milk. *RS* values for each cheese were calculated by substituting the *RF* and *RC* values into the following equation:

$$RS = \frac{RF \times \% \text{ Fat in milk}}{[(RF \times \% \text{ Fat in milk}) + (RC \times \% \text{ Casein in milk})] \times FDM}$$

where fat in dry matter (**FDM**) was determined experimentally as follows:

$$FDM = \frac{\% \text{ Fat in cheese}}{(100 - \% \text{ Moisture of cheese})} \times 100$$

The fat, casein, and solids retention factors and cheese yields are shown in Tables 8 and 9. Composition adjusted cheese yields (CACY) were calculated at 39% moisture for hard-pressed cheese and 50% for the soft ripened cheese. Substantial differences in composition-adjusted % cheese yields, and small differences in % fat and % nitrogen recoveries between trials, indicate that differences in milk composition (casein and fat) was the major factor responsible for differences in cheese yield.

Table 10 lists the recommended retention factors to be used for estimation of cheese yields for hard and soft cheeses from sheep milk. Factors may have to be adjusted slightly for late lactation milk.

Conclusion

Results of this study showed that seasonal changes had a significant impact on milk composition, thereby affecting cheese yield. Cheese yields were directly related to the level of fat and casein in the initial milk. However, fat and protein recoveries in the cheese were not significantly different over the season. Results of the study showed that the Van Slyke-Price cheese yield formula could be effectively used to predict cheese yield for hard-pressed and soft cheeses made from ovine milk. The future potential for production of high quality specialty products from sheep milk is very promising. However, proper handling and storage of the milk through the manufacturing process is critical to the overall quality and yield of processed products.

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Table 1. Milk Composition - 2002.

	February milk	May milk	August milk
Total solids, %	19.28	18.81	17.29
Milk fat, %	7.58	6.74	6.59
True protein, %	5.33	5.27	5.09
Casein, %	4.34	4.33	4.25
Casein:fat ratio	.57	.65	.64
SCC/ml ¹	480,000	360,000	390,000

¹ SCC = Somatic cell count**Table 2.** Milk Composition - 2003.

	January milk	May milk	September milk
Total solids, %	17.88	16.61	17.70
Milk fat, %	6.38	5.92	6.77
True protein, %	5.23	4.79	5.48
Casein, %	4.37	4.02	4.52
Casein:fat ratio	.68	.68	.67
SCC/ml ¹	310,000	400,000	470,000

¹ SCC = Somatic cell count

Table 3. Composition of Hard Pressed Sheep Milk Cheese Before Brining and Ripening

	February milk	May milk	August milk
Moisture, %	38.70	38.78	39.40
Fat, % ¹	34.46 ^a	32.78 ^b	32.53 ^b
Protein, % ^{1,2}	22.63 ^b	24.19 ^a	23.59 ^a
FDM, % ^{1,3}	56.22 ^a	53.54 ^b	53.68 ^b

¹ Means within the same row without a common superscript differ ($P < 0.05$).

² Total % N X 6.31.

³ Fat in the dry matter.

Table 4. Composition of Soft Sheep Milk Cheese Before Brining and Ripening

	January milk	May milk	September milk
Moisture, %	54.72	49.95	50.82
Fat, %	24.93	27.42	26.85
Protein, % ^{1,2}	16.74 ^b	20.78 ^a	18.33 ^b
FDM, % ³	55.08	54.80	54.68

¹ Means within the same row without a common superscript differ ($P < 0.05$).

² Total % N X 6.31.

³ Fat in the dry matter.

Table 5. Impact of Milking Season on Fat and Nitrogen Recovery in Hard Pressed and Soft Ripened Cheese

	Early	Mid	Late
	----- (%) -----		
Fat recovery			
Hard Cheese	83.8	84.2	83.2
Soft Cheese	82.3	80.4	81.8
N recovery			
Hard Cheese	73.0	75.2	73.8
Soft Cheese	63.4 ^b	71.7 ^a	65.8 ^b

Table 6 Fat and Protein Recovery in Sheep Milk Cheeses

Reference	% Fat Recover	%Protein Recovery
Hard Cheese	83.2-84.2	73.0-75.3
Pirisi et al.	78.0-81.4	75.4-79.5
Soft Cheese	80.4-82.3	63.4-71.7
Gonzalez, et al..	65.0	65.0
Economides, et al.	86.9	78.6

Table 7. Cheese Yield and Retention Factors for Hard Pressed Cheeses

	February milk	May milk	August milk
<i>RF</i> value	0.84	0.84	0.83
<i>RS</i> value	1.07	1.08	1.08
<i>RC</i> value	.96	.96	.94
Actual yield, %	18.45	17.29	16.78
CACY, % ¹	18.52	17.38	16.75
FDM, %	56.2	53.5	53.7

¹ CACY = Composition-adjusted cheese yield at 39% moisture.

Table 8. Cheese Yield and Retention Factors for Soft Cheeses

	January milk	May milk	September milk
<i>RF</i> value	0.82	0.81	0.82
<i>RS</i> value	1.01	1.01	1.03
<i>RC</i> value	.96	.96	.94
Actual yield, %	21.08	17.35	17.35
CACY, % ¹	19.09	17.37	17.06
FDM, %	55.1	54.8	54.7

¹ CACY = Composition-adjusted cheese yield at 39% moisture.

Table 9. Recommended Retention Factors for Van Slyke Yield Formula

	Hard cheeses	Soft cheeses
<i>RF</i> value	0.84	0.82
<i>RS</i> value	1.08	1.01
<i>RC</i> value	.96	.96
