Cheese from Pastured Cows:
Comparing taste, texture and color

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Introduction

The market for specialty cheese, including pasture-based cheese, is growing rapidly. A California Milk Advisory Board study found that U.S. specialty cheese consumption increased five times faster than total cheese consumption between 1994 and 2003; production totaled 815 million pounds in 2003, with an estimated value of $6.4 billion. According to the Wisconsin Specialty Cheese Institute, 331 million pounds of specialty cheese were produced in Wisconsin in 2004; this accounted for 14 percent of the state's total cheese production.

In order to take full advantage of the pasture-based portion of the specialty cheese market, graziers, cheesemakers and marketers need to know how this type of cheese is unique. Does it look and taste different than other cheeses? What are its unique processing qualities?

This report describes research on the taste, texture and color of cheese made from the milk of pastured dairy cows. The research was funded by the Wisconsin Milk Marketing Board, the USDA Cooperative State Research, Extension and Education Service (CSREES) and the Center for Integrated Agricultural Systems (CIAS), University of Wisconsin-Madison. The raw milk characteristics were examined by David Combs of the Department of Dairy Science, UW-Madison. Cheese characteristics were examined by Scott Rankin and John Lucey of the Department of Food Science, UW-Madison. Tasting panels were led by MaryAnne Drake of North Carolina State University. The project was facilitated by CIAS with input from an advisory group of dairy farmers and representatives of the state's specialty cheese industry. It was initiated in the summer of 2003.

Methods

The overall objective of this research was to determine if cheese made from the milk of exclusively grazed dairy cows tastes different than cheese made from the milk of cows fed a silage-based ration or cows that are grazed and have diets supplemented with grain. Feeding and cheesemaking trials were repeated several times each grazing season. The 2003 season yielded some successes; however, due to drought and the resulting loss of grazing forage, the trial was postponed until 2004. In an effort to increase the number of replicates, the number of milk and cheese samples was doubled in 2004. In 2005, the latter half of the study was again influenced by dry weather. Experimental details of this work include:

Feeding Treatments: Milk was received from three separate feeding systems: 1) cows fed a grain-based Total Mixed Ration (TMR) with alfalfa silage as the sole forage source. TMR combines forages, grain, minerals, vitamins and protein supplements in one mixture; 2) cows grazing a grass-legume pasture and offered a corn-based supplement at approximately 40% of ad libitum intake; and 3) cows grazing a grass-legume pasture with no grain supplement.

Grazing Methods: The cows were grazed under a managed grazing system at the UW Arlington research station, which is set up for pasture studies. Mixtures of kura clover (variety: Endura) with low endophyte tall fescue (variety: Palaton) were established in pastures at the Dairy Cattle Research Center at Arlington in March, 1999. Portable front and back fences were used to control the quality and amount of herbage consumed by the cows. Fresh pasture was offered twice daily on the paddocks by moving a front fence, and a back fence was moved three times a week to limit grazing of forage regrowth. To allow uniform regrowth and to maintain pasture quality, the paddocks were divided into three sections that were mechanically clipped at 28, 21, and 14 days before the start of the trial. Thus, cows grazed on forage between 14 and 21 days of regrowth.

Animals and Experimental Procedure: In 2004 and 2005**,** fifteen primiparous, lactating Holstein cows were used in a replicated 3 x 3 Latin Square statistical design. Different groups of cows were used each year. Cattle and treatments were randomly assigned within each square. All cows received all treatments by the completion of the study. Treatments consisted of the three feeding systems described above. The TMR and pasture plus grain treatments contained adequate energy, protein, vitamins and minerals to support 65 lb of 4 % fat-corrected milk (FCM)[1] daily according to National Research Council guidelines.

Milk Collection and Processing: Milk was sampled and production measured for two consecutive days (four milkings) at the end of each 21-day experimental period. Individual milk samples were analyzed for fat, true protein and somatic cells by near infrared analysis (AgSource, Verona, WI). In 2004 and 2005, Cheddar cheese was made multiple times using milk from each of the three treatments over a period of approximately 2 months. For cheesemaking, a composite of the milk from four milkings of each treatment was used. Thus, three cheeses were made at the end of each 21-day trial. The cheese was made in the UW-Madison Department of Food Science. Miniature scale (5 gal) cheese vats were used.

Results and Discussion

Raw Milk Composition: Milk production data for 2004 and 2005 are outlined in tables 1 and 2 on page 3. Because the 2005 drought reduced the feed intake of the pastured cows, yield and composition data are shown for each year.

[1] Fat-corrected milk is a means of standardizing milk production to compare milk yield after adjusting the milk to the same fat content. The formula for 4%FCM is: (pounds of milk x 0.4) + (lb of milk fat x 15).

Results from the 2004 grazing season, which ran from May 5 through July 15, are summarized in Table 1, below. As expected, milk production decreased when cows were fed only pasture. Milk production from cows fed pasture plus supplemental grain and cows fed TMR was similar. Milk protein concentrations were lowest in cattle offered pasture with no supplement. This is likely due to an energy imbalance caused by lower total daily energy intake when cattle have no access to supplemental grain. Milkfat composition was similar for cows fed pasture only and TMR, and the milkfat percentage of cows receiving pasture plus supplemental grain was lower than the other two treatments. This suggests that when grain is offered, pasture intake, and therefore fiber intake, may limit optimal milkfat synthesis.

Table 1. Milk yield and composition from cows fed exclusively on pasture, pasture with a grain supplement, or an alfalfa-based total mixed ration. Summer 2004.

	Pasture only	Pasture + Grain	TMR	SE
Milk yield, lb	38.0[a]	63.0[b]	58.0[b]	1.7
4% FCM, lb	37.0[a]	57.0[b]	57.0[b]	1.2
Milk composition				
True protein, %	3.0[a]	3.12[b]	3.09[b]	0.07
Fat, %	3.8[b]	3.4[a]	3.9[b]	0.1
SCC, x 1000*	244.0	74.0	109.0	39.0
Milk Urea Nitrogen (MUN)	20.3	19.1	20.5	0.7

[ab] Means in rows with different superscripts differ (P<0.01) *SCC for all treatments indicates high-quality milk. The differences in SCC have minor biological significance.

Table 2. Milk yield and composition from cows fed exclusively on pasture, pasture with a grain supplement, or an alfalfa-based total mixed ration. Summer 2005.

	Pasture only	Pasture + Grain	TMR	SE
Milk yield, lb	48.0[a]	66.0[b]	64.0[b]	2.1
4% FCM, lb	42.0[a]	59.0[b]	62.0[b]	2.2
Milk composition				
True protein, %	2.66[a]	2.74[b]	2.84[b]	0.06
Fat, %	3.41[a]	3.36[a]	3.84[b]	0.11
SCC, x 1000	47.0	52.0	57.0	13.0
Milk Urea Nitrogen (MUN)	16.8	17.3	16.0	0.9

[ab] Means in rows with different superscripts differ (P<0.01)

Somatic cell counts (SCC) and milk urea nitrogen levels (MUN) did not differ among treatments. These results suggest that we were able to sustain milk production on pasture when about 40% of the cows' intake was supplemental grain. This amount of grain was similar to that offered to the cattle fed the TMR diet.

In 2005, drought conditions at the Arlington station severely limited pasture growth and, subsequently, the timing of the experiment. Periods one and two of the feeding trial were conducted from May 25 through July 7. The trial was then suspended to allow pastures to recover, and the final period of the experiment took place between August 25 and September 12. The same group of primiparous cows was used in all three periods of the 2005 trial.

Milk production in 2005 was similar for cows consuming pasture plus grain supplement and the TMR diets (Table 2, page 3). As in 2004, cows consuming pasture with no supplement produced approximately 30 % less fat-corrected milk per day. The loss in milk production when no supplement was fed may have been

Table 3. Cheddar cheese scores. Evaluation by a trained sensory panel.

	Pasture only	Pasture + Grain	TMR
Cooked	3.0[a]	2.9[a]	3.1[a]
Whey	**2.1[b]**	**2.3[ab]**	**2.5[a]**
Diacetyl (buttery)	**0.0[b]**	**0.5[a]**	**0.5[a]**
Milkfat	**3.2[b]**	**3.2[b]**	**3.4[a]**
Fruity	0.0[a]	0.0[a]	0.0[a]
Sulfur	**1.0[a]**	**1.0[a]**	**0.65[b]**
Free fatty acid	0.0[a]	0.0[a]	0.0[a]
Brothy	**1.3[a]**	**1.2[a]**	**0.80[b]**
Nutty	0.0[a]	0.0[a]	0.0[a]
Catty	0.0[a]	0.0[a]	0.0[a]
Cowy/barny	0.0[a]	0.0[a]	0.0[a]
Grass aroma	**1.7[a]**	**1.3[b]**	**0.0**
Sour	3.1[a]	3.1[a]	3.1[a]
Salty	3.9[a]	3.9[a]	3.8[a]
Bitter	0.0[a]	0.0[a]	0.0[a]
Sweet	2.1[a]	2.2[a]	2.2[a]
Umami (savory)	1.7[a]	1.8[a]	1.8[a]

Higher values represent higher attribute perception. Letters next to values represent significant differences at the 95% confidence level. Values in boldface are significantly different at the alpha<0.05 level.

especially severe because of the drought and limited pasture availability. Milkfat content was lower for both pasture groups than the TMR group, which suggests that cows offered pasture were consuming less fiber per day than cows on the TMR diet. We did not measure pasture intake directly during the grazing study.

Cheese composition varied for several reasons. Cheese yield from the milk of cows fed exclusively on pasture was 10-15% lower compared to milk from the cows fed TMR and pasture plus grain. No significant differences in the protein or moisture content of the cheeses were observed as a result of the treatments. There was some experimental variation, primarily due to the manufacture of cheese in small vats where pressure, whey drainage and cutting are difficult to control. Milk and cheese showed significant color differences based on feed. The cheese made from the milk of supplemented, pastured cows was darker, redder and yellower than the relatively whiter TMR counterpart, with the color of cheese from the pasture-only cows falling between these two treatments. Cheese color was evaluated with a colorimeter (see Figure 2, page 6).

Flavor perception was evaluated by both a trained sensory panel and a consumer panel. The cheeses were aged at seven degrees Celsius between two and four months and were then sent to North Carolina State University for trained panel analysis using a Cheddar cheese lexicon. This panel found significant differences in flavor perception among the cheeses. (Table 3, page 4). The TMR cheese was slightly higher in whey and milkfat aroma. There was a higher level of diacetyl, which imparts a buttery flavor, in the TMR and pasture plus grain cheeses. The cheese made from the milk of pastured cows had slightly higher sulfur and brothy notes. Across all cheese ages, cheese from the two grazing treatments had a significant grassy note; this attribute was higher in the cheese from pasture-only cows.

Consumer liking scores (n=85) were generated at North Carolina State University using approximately three month-old cheese. Consumers tended to give the cheese made from the milk of pastured, supplemented cows the highest scores relative to flavor, texture and overall liking (Table 4, below). When asked a forced choice preference question, 60% of consumers preferred this cheese. Demographic information and consumption characteristics of these consumer panelists are described in Table 5, page 7.

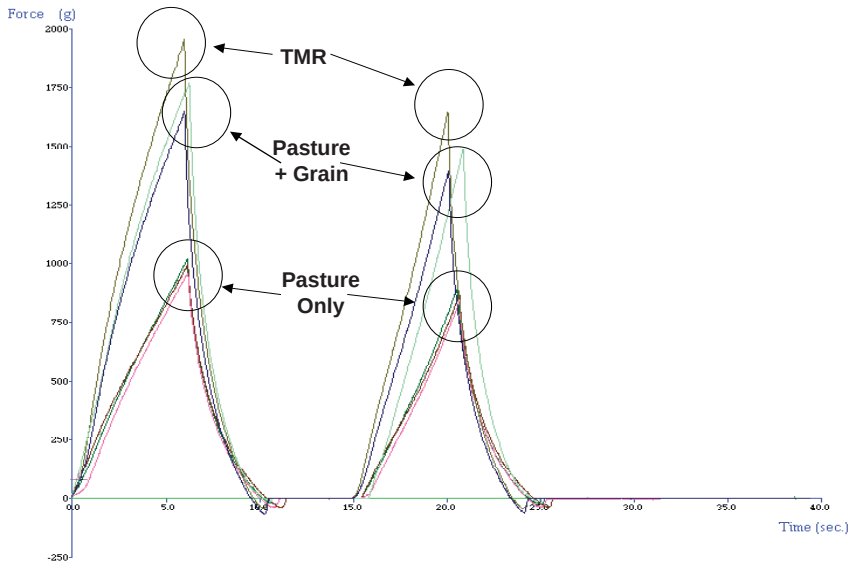
Table 4. Liking scores from a consumer panel evaluation.

	appearance	flavor	texture	overall
Pasture only	6.6[a]	5.7[b]	4.3[b]	4.9[b]
Pasture + grain	6.9[a]	6.5[a]	5.2[a]	6.0[a]
TMR	6.8[a]	5.8[b]	4.7[b]	5.2[b]

The cheeses were evaluated on a 9-point hedonic scale, where 9 was “like extremely” and 1 was “dislike extremely.” The values reported are mean values. Means in a column followed by different letters are different ($p<0.05$)

Textural differences were observed between the cheeses resulting from all three treatments (Figure 1, below). The cheese made from the milk of pasture-only cows was consistently softer than cheese from the other two treatments. The reasons for this are somewhat unclear, but may relate to the exclusively pastured product having more unsaturated fatty acids (as reported in the literature), thus being softer (due to an altered solid fat index) at a given temperature. The softer texture may also relate to a change in the casein micelle structure, yielding a curd with reduced firmness.

Figure 1. Texture analysis of cheese samples. Lower peak force values relate to softer cheese texture.



Color Differences: Major color differences were apparent at every cheesemaking trial. Confirmed by colorimetric analysis, the TMR cheese was generally whiter, the cheese from cows fed pasture with grain supplement was the most yellow, and the cheese from cows fed exclusively on pasture was intermediate in color (Figure 2, below).

Figure 2. Color images of the three cheese types depicting the differences in hue.

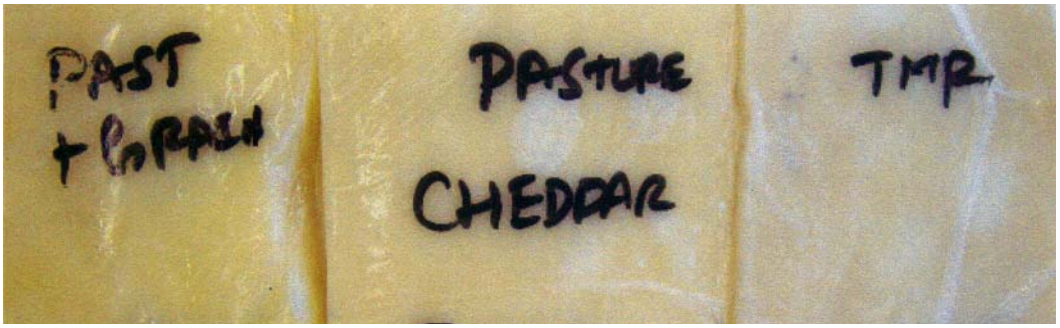


Table 5. Panelists: Demographic information and cheese consumption

Number of panelists	85
Gender (% males/females)	37/63
Age group	0 %≤ 18 y 38 % 19-25 y 30 % 26-35 y 18 % 36-45 y 10 % 46-55 y 4 % > 56 y
Shop for household (% yes/no)	93/7
Cheese consumption	0 % never 5 % once per mo 34 % 2-4 times per mo 61 % > once per wk
Cheese types consumed*	67 % Mild/young Cheddar 69 % Sharp aged Cheddar 27 % mild/young Gouda 27 % Sharp aged Gouda 59 % Swiss 71 % Parmesan 56 % Processed cheese 27 % Monterey Jack/Colby 36 % Bleu cheese 54 % Cottage/Ricotta 65 % Cream cheese 73 % Mozzarella
How do you use cheese?	85 % alone or with other foods as a snack 85 % as a topping 79 % as an ingredient 83 % in sandwiches
Purchase/consumption of reduced or low fat cheese	66% yes
Purchase/consumption of organic cheese	32% yes
Purchase/consumption of raw milk cheese	27% yes
Factors influencing choice of cheese*	97 % flavor 64 % price 42 % freshness 29 % health/nutrition 18 % brand name 54 % appearance 61 % intended use

*Consumers were allowed to choose more than one category, so category percentages do not add up to 100.

Identification of the grassy flavor compound(s) continues to be a challenging component of this research. We have completed ten solvent-assisted flavor extractions on the cheeses and have run approximately fifty chromatography runs (both with mass spectrometer and the olfactory port). From this work, we have been able to identify numerous potent odorants. A single, identifiable compound that is the root cause of the grassy note has not been identified. The grassy note may be generated by a combination of several compounds. The grassy note is definitely volatile, appears to be somewhat heat labile, and is clearly identifiable by sensory inspection in the extracts from the cheese of all of the pastured cows. Contrary to previous research, we have not been able to locate any alkylphenols, having looked specifically for these compounds at levels well below their sensory threshold.

Our current work involves the treatment of the cheeses with enzymes designed to hydrolyze the alkylphenol conjugates. Such work has yielded some findings. First, the alkylphenol 4-methylphenol is present in all of the cheeses. We have not been able to confirm the nature of the conjugated form. Second, the compound 3-methylphenol has been found only in the milk from grazing animals. This compound, when introduced into bland cheese, has sensory properties similar to that of the cheese from the two pasture treatments. Further work will be needed to confirm its role in producing the grassy flavor.

Future Research Directions

Biophysical/Nutritional Research

- Explore cheese variations related to region of the state, season and pasture mix. This would include evaluation of cheese from cows grazed on farms, on pastures with diverse grass species, for extended durations, rather than grazed at an experiment station and switched between treatments.
- Evaluate cheeses made by expert cheesemakers.
- Further refine understandings of the relationship between levels of supplemental feeding and the maintenance of the "grassy note" to match levels of supplemental feeding normally done by Wisconsin graziers.
- Further investigate the aging properties of pasture-based cheese.
- Evaluate human nutritional characteristics of pastured cheese, including a review of the literature and a follow-up to the Union of Concerned Scientists report on pasture-based food products[2].

Socioeconomic/Marketing Research

- Evaluate the market for pasture-based cheese in the Upper Midwest, including interviews with buyers from both food service and retail businesses.

[2]Clancy, Kate. 2006. *Greener Pastures: How Grass-Fed Beef and Milk Contribute to Healthy Eating.* Union of Concerned Scientists.

- Follow-up on the North Carolina taste panel with a focus groups of consumers.
- Locate Wisconsin in the national context of the cheese industry and specialty cheese (relative to California and Vermont). Relate cheese making/marketing structure and farm structure. Evaluate where Wisconsin can compete and where we can collaborate with other states.