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Producing smear-ripened sheep milk cheese—Is it possible?

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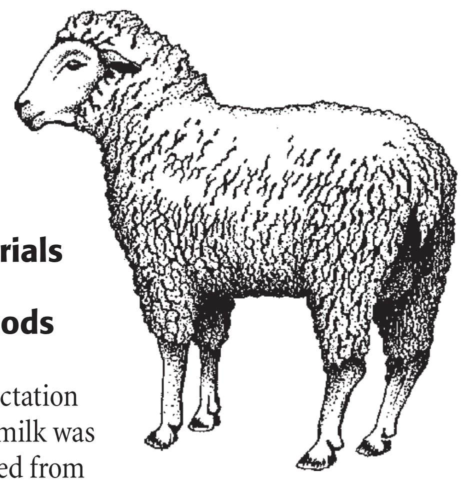
Brick and limburger are two popular examples of smear-ripened cheeses made from cows milk. Can other milks be used to make a smear ripened cheese? After several cheesemakers told us of problems they encountered trying to produce a smear-ripened sheep milk cheese we began to wonder. The cheesemakers reported that it was difficult to get the smear organisms to grow on the surface of sheep milk cheese as they tried to produce cheese with the desired flavor and aroma of a typical smear-ripened cows milk cheese.

We turned to the World Cheese Exchange Database on the Center for Dairy Research website and found 32 of 779 cows milk varieties of cheese were smear-ripened, 3 of 282 goat milk varieties were smear-ripened but of 279 sheep milk varieties of cheese, none were smear-ripened. Our search also turned up 76 cows milk cheeses, 13 goats milk cheeses and 15 sheep milk cheeses that were washed rind cheeses.

Traditional smear-ripened brick cheeses

We wanted to know why cheesemakers were having a difficult time producing a smear-ripened sheep milk cheese and, also, is it even possible to produce such a traditional cheese from sheep milk? We decided to produce traditional smear-ripened brick cheeses from both cows milk and sheep milk to determine how a sheep milk cheese would compare to a cows milk cheese in a traditional smear-ripening process.

What's Inside:



Materials and methods

Mid-lactation sheep milk was obtained from the University of Wisconsin Experimental Station at Spooner, Wisconsin. The milk was immediately cooled to 32ºF and transported to the laboratory in Madison. The raw milk was packaged in 35 lb heavy duty polyethylene bags and rapidly frozen in a commercial freezer at -16ºF. Milk was stored at-16ºF for 2 months prior to cheese manufacture. Previous studies have shown that raw sheep milk could be stored frozen for several months at – 4ºF without significant impact on milk composition or cheesemaking properties (Bastian, 1994; Wendorff, 2001). Raw cows milk was obtained from the University of Wisconsin Babcock Hall Dairy Plant.

Cheese manufacture and sampling

Prior to cheesemaking, the sheep milk was thawed at 45ºF over a 3-day period. Two licensed Wisconsin cheese makers manufactured the brick cheeses in the University of Wisconsin dairy processing pilot plant. One vat each of cows milk (500 lbs of milk) and sheep milk (200 lbs) brick cheese were made from the unstandardized whole

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Dairy Markets and More

by Brian W. Gould, Associate Professor, Agricultural and Applied Economics University of Wisconsin—Madison

In this issue of Dairy Markets and More, I would like to review recent trends in milk production across the United States and show you that the ability of the U.S. dairy farm operator to respond to changing market conditions is truly amazing. For example, Figure 1 shows the total productivity of U.S. dairy producers over the 33-year period 1975-2007.[1] Compared to the total output in 1975, total milk production in 2007 was over 60% greater. This increase wouldn't be so startling, but it happened with 19% fewer cows in the U.S. That's right, the annual average productivity per cow almost doubled, increasing from 10,311 lbs/cow in 1975 to an average production of 20,266 lbs/cow in 2007.

The annual values shown in Figure 1 hide some distinctive patterns of monthly variation in productivity. These patterns become more clear in Figure 2, which shows monthly U.S. milk production after we standardize for 30-day months over the Jan. 2005-Jan. 2008 period. Now you can see several patterns, including: the phenomenon of the annual spring productivity growth, the continued pattern of a general increase in production shown in Figure 1, and the inability of the linear trend to explain the growth in monthly production. The trend line, shown in blue, only accounts for 22% of the variability in monthly production.

Because of the seasonality shown in Figure 2, when examining monthly milk production we often generate *year-over-year* comparisons of the monthly series. For example, if we compare the Jan 2008 U.S. milk production value with the Jan. 2007 value we see a 1.95% increase. Figure 3 shows the pattern of the total year-over-year monthly percentage change in total U.S. milk production and the top line shows these values. Note that the values of these percentage changes are determined by both the level of the production in the previous year (e.g., was production low or high in the previous year) and the growth in production in the current year. When analyzing these trends, given the length of time it takes to adjust the herd size, you need to examine market conditions 1 to 2 years prior to current production to understand the reasons for the

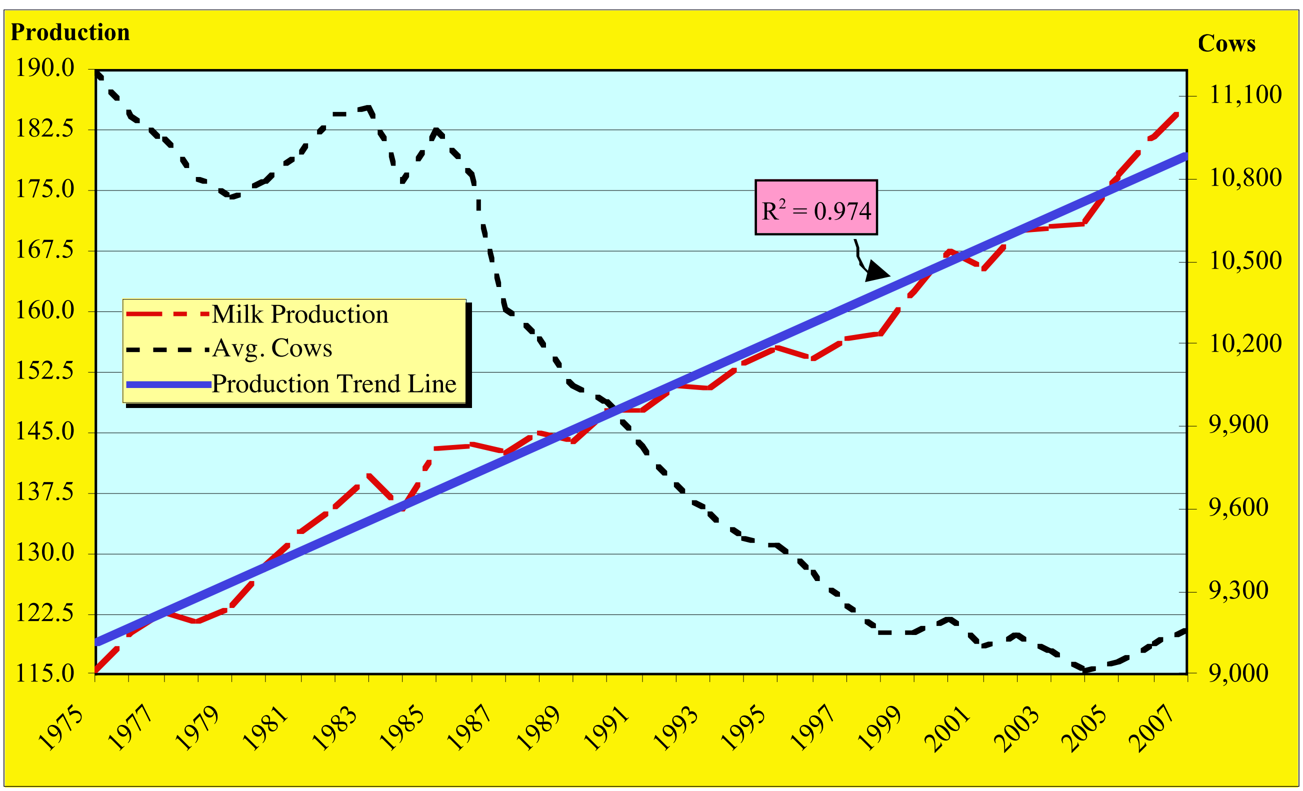

Figure 1. Annual U.S. milk production (Billion Lbs) and number of dairy cows (1,000)

[1] The R^2 measure shown in Figure 1 is associated with the trend line and represents the percent of the total variation in U.S. milk production explained by the trend line. The range in values is 0-1 with the higher the value the better. Over 97% of production variability is accounted for by trend.

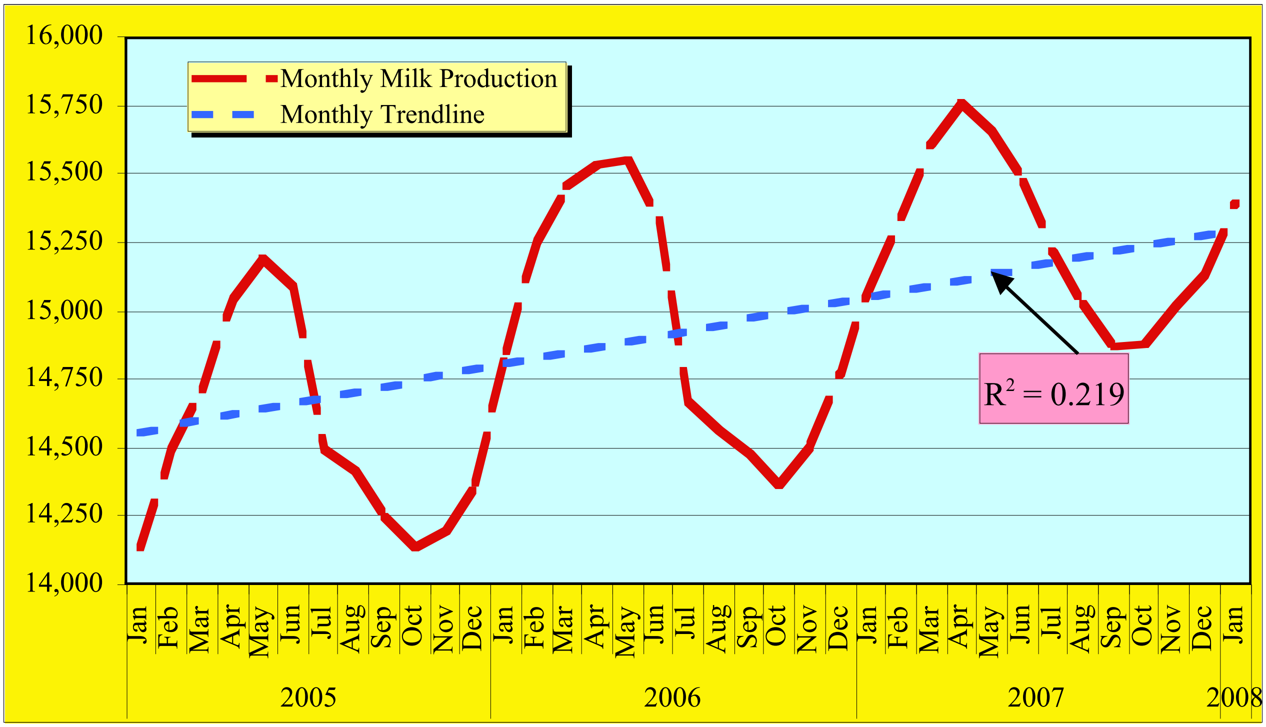

Figure 2. Monthly U.S. milk production (Mil. Lbs., 30-Day Months)

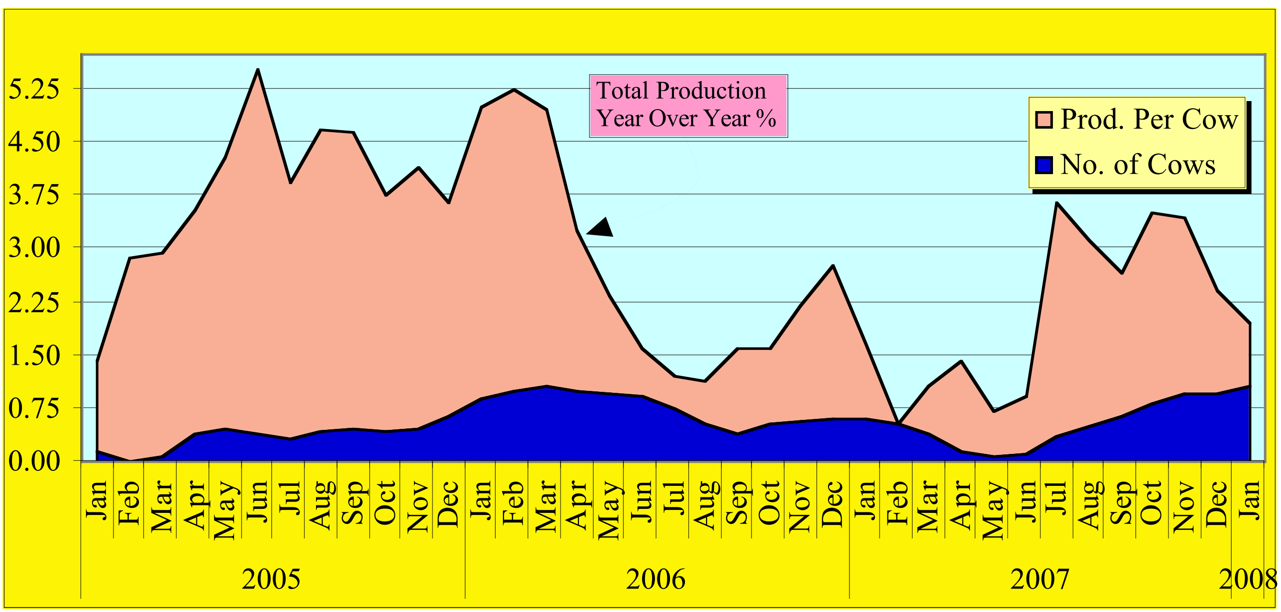

Figure 3. Year-Over-Year % change in monthly U.S. milk production by source of change

observed growth patterns. For example, Federal and California classified pricing rules and the cost of heifers, feed, etc. all influence the rate of growth.

In addition to the overall change in U.S. milk production, Figure 3 shows that a majority of the year-over-year growth in U.S. production is due to increased yield per cow rather than an increase in the number of cows. During the January 2005 to January 2008 period, over 75% of the observed year-over-year increase was due to change in productivity per cow. The question remains, with improved genetics and nutrition management, where will the U.S. average per cow productivity be in the next 5 – 10 years? The implications for U.S. milk production are obvious. In a future ***Dairy Markets and More*** we will examine regional differences in milk production patterns.

For more information with about U.S. milk production, refer to the University of Wisconsin *Understanding Dairy Markets* website which can be found at: http://future.aae.wisc.edu .

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milk. Milk for each vat was pasteurized at 160ºF/19s and cooled to 90ºF before inoculation. The cows milk was inoculated with 0.01% direct vat set culture of *Streptococcus thermophilus* Cargill TD 17 (Cargill, Waukesha,WI). The culture addition to the sheep milk was adjusted so the amount of culture added per unit of casein was equivalent to that of the cows milk. The milk was ripened for 60 min at 90ºF before Double Strength Chymax Extra' (Chr. Hansen, Inc., Milwaukee, WI) was added to the milks. The coagulant was added at a rate of 19 ml/500 lb for cows milk and the coagulant addition to sheep milk was again adjusted to match the coagulant addition per unit of casein of the cows milk. Both starter and coagulant addition were based on total casein content of each of the milks to provide for an equivalent addition of ripening agents to substrate for both of the milks. The experienced licensed cheesemakers subjectively evaluated coagulum development and determined the proper coagulum firmness for cutting. The cows milk coagulum was cut with 3/8 inch knives and the sheep milk coagulum was cut with 1/2 inch knives. Sheep milk curd typically exhibits a faster rate of syneresis so we cut larger sized curds with the sheep milk to produce cheeses with comparable moisture levels. The curd was cooked at 104ºF for 30 min and was drained when it reached a pH of 6.2. The curd was dipped into 5.5 lb brick hoops and held at 68ºF overnight.

"The cheeses were transported to Chalet Cheese Coop in Monroe, WI for the traditional smear treatment."

The cheeses were then transported to Chalet Cheese Coop (Monroe, WI) for the traditional smear treatment. The cheeses were dry-salted and placed in a 63ºF smear room that had a relative humidity of 95-100%. At regular intervals, the cheeses were turned and washed with a proprietary combination of smear organisms in a 3-6% salt solution. Each cheese received 8 smear washes over a 2 wk period and was also moistened daily over that time period. After two weeks of manufacture, the cheeses were wrapped in the conventional manner with an underwrap of parchment and an overwrap of aluminium foil. The cheeses were then transported back to Babcock Hall Dairy Plant where the cheeses were placed in a 46ºF aging room for further development. Samples were taken at regular intervals for analysis and sensory evaluation.

Milk and cheese analysis

All compositional analyses were carried out on the cheeses in triplicate. Pasteurized milk samples were analyzed for total solids (Green and Park, 1980), fat by Mojonnier, Procedure 989.05 (AOAC, 2000), protein (total percentage N x 6.35) by Kjeldahl, Procedure 991.20 (AOAC, 2000) and casein, Procedure 998.50 (AOAC, 2000). Non-protein nitrogen (NPN) of the milks was also

Table 1. Composition of cow and sheep milk used for smear-ripened brick cheese.

	Cows milk	Sheep milk
Total solids, %	11.86	17.04
Milk fat, %	3.43	6.52
Total protein, %	3.09	5.00
True protein, %	2.89	4.73
Casein, %	2.39	3.89
Casein /true protein, %	82.70	82.24
Casein:fat ratio	0.70	0.60

Table 2. Composition of smeared brick cheeses at 2 weeks of age.

	Cow	Sheep
Moisture, %	42.07	40.79
Milk fat, %	29.44	33.91
Protein,[1] %	21.65	20.97
Salt, %	1.65	1.55
MNFS,[2] %	59.63	61.72
FDM,[3] %	50.83	57.27
S/M,[4] %	3.92	3.80

[1] Total % N X 6.31.
[2] Moisture in nonfat substance.
[3] Fat in the dry matter.
[4] Salt as a percentage of the moisture phase.

measured using the method described by Johnson et al. (2001). Cheeses were analyzed after the smear treatment for moisture by vacuum oven (Marshall, 1992), fat by Mojonnier, Procedure 933.05 (AOAC, 2000), pH by the quinhydrone method (Wehr and Frank, 2004), salt by chloride electrode method (model 926; Corning Glass Works, Medfield, MA; Johnson and Olson, 1985) and protein (total percentage N x 6.31) by Kjeldahl, Procedure 991.20 (AOAC, 2000).

Microbiological analyses conducted on the cheeses included: yeast and molds on yeast extract glucose chloramphenicol agar (Wehr and Frank, 2004), salt tolerant bacteria on MPCA-5 agar (Brennan et al., 2002), and *Brevibacterium spp* (Leclercq-Perlat et al., 2002).

Results And Discussion

Average composition of the pasteurized cows milk and sheep milk is shown in Table 1. Sheep milk contained higher solids, fat, protein, and casein than cows milk. Casein/true protein percentage was comparable for both milks and, since there was a significant difference in casein content between the cows and sheep milk, the starter and coagulant were adjusted so that the amount of culture and coagulant per unit of casein were the same for both cheeses. This was designed to produce an equivalent chemical and enzymatic treatment of the cheese proteins during the curing process.

Cheese composition

Sheep milk cheese had higher fat and lower protein than the cows milk cheese (Table 2). This was the result of having sheep milk with a lower casein/fat ratio. Moisture, salt and S/M percentage were not significantly different between the two cheeses. The body of the sheep milk cheese was much firmer than the cows milk cheese. This was most likely due to the higher α_{s1} casein and higher calcium content in sheep milk (Anifantakis, 1986). Kalatzopoulas (1970) noted that curd from sheep milk obtained a final firmness twice that of curd from cows milk due to the differences in the casein systems of the two milks.

Microbial growth of smear organisms on sheep milk cheese was comparable to that of the cows milk cheese over the 6 month aging period (Figure 1). In smear-ripened cheeses, yeast will typically

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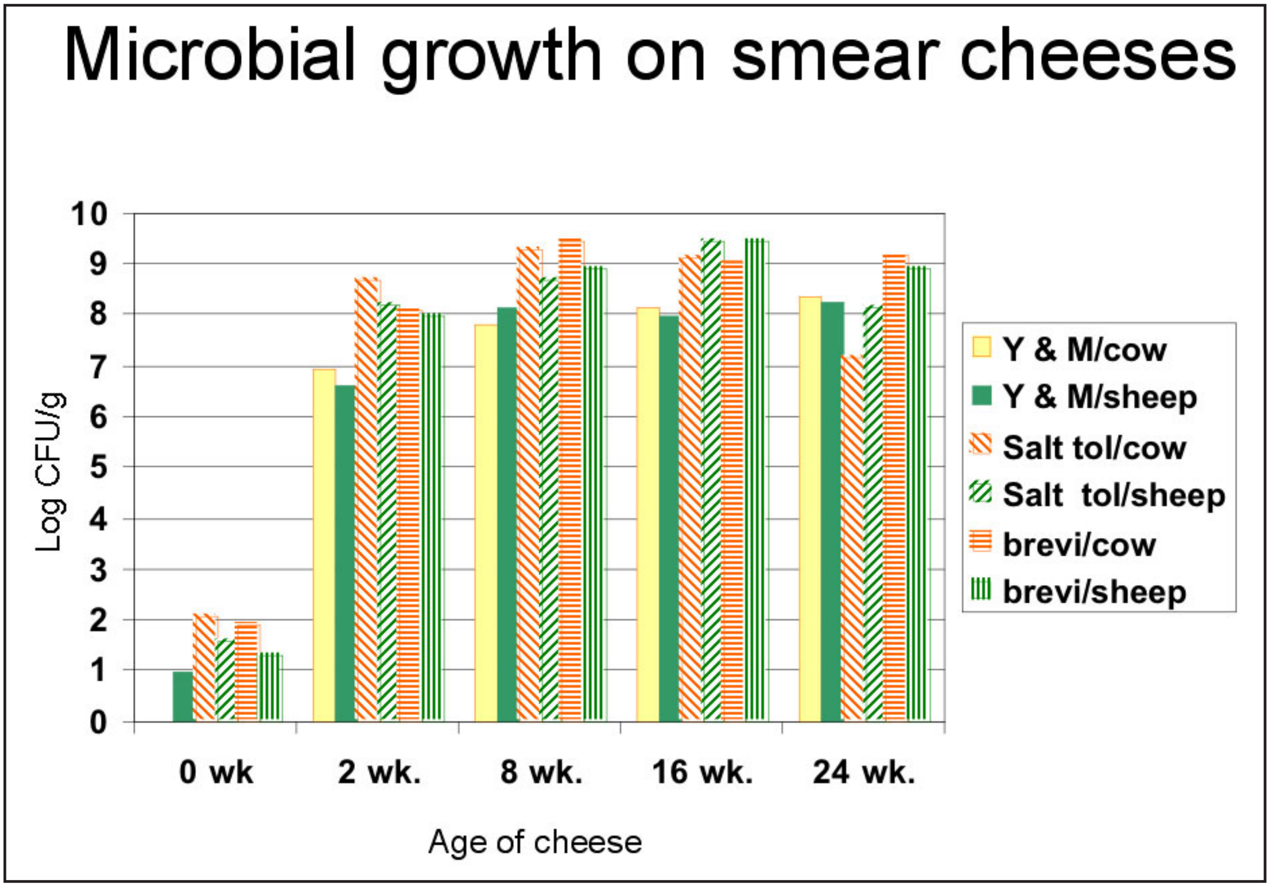
Figure 1.



grow first and use some of the lactic acid to bring the pH of the cheese surface above 6.0 (Bockelmann, 1999). The yeast also synthesizes vitamins that stimulate the growth of smear bacteria. Salt tolerant bacteria, e.g., *Coryneform* bacteria and micrococci will also begin to grow on the cheese surface and hydrolyze proteins by releasing ammonia, which also increases the surface pH of the cheese. When the surface pH reaches 6.0, *Brevibacterium linens* will begin to grow and produce the typical volatile aromatic sulfur compounds of smear cheeses. The pattern of development of the yeasts and smear organisms appeared to be consistent for the cows and sheep milk cheeses throughout the aging period.

Sensory evaluation

Sensory evaluation of the two cheeses was conducted at 8, 16, and 24 weeks of age. At 8 weeks, the cows milk cheese had a clean lactic flavor typical of a mild brick cheese while the sheep cheese had a slight acid flavor with a very slight bitter note. The body of the cows milk cheese was slightly firm while the body of the sheep cheese was definitely firm. The difference in body was consistent with the difference experienced in the initial cheeses as a result of the higher α_{s1} casein content of the sheep milk. Addition of the starter and coagulant was based on the total casein content of the milks; however, sheep milk typically has over 50% more α_{s1} casein than cow milk (Anifantakis, 1986). In a previous study (Ponce de Leon-Gonzalez et al., 2002), we found that α_{s1} casein in reduced-fat muenster cheese was completely hydrolyzed at 120 days of age while in a similar cheese containing 80% cow milk/ 20% sheep milk, the α_{s1} casein was completely hydrolyzed after 180 days. At 16 weeks, the cows milk cheese had the typical body and flavor of a smear-ripened brick cheese. The sweet, sulfury, pungent flavor had permeated to the inner portion of the cheese. The sheep milk cheese had the typical brick flavor at the surface of the cheese but the body was still much firmer than the cows milk cheese. The interior of the cheese had a mild brick flavor, with a slight oxidized flavor from the sheep milk fat. At 24 weeks, the cows milk cheese had a slight ammonia odor and a musty and slight bitter flavor. The body of the cheese was still acceptable. The sheep milk cheese had a good clean brick type flavor with a slight hint of sheep fat. The body of the cheese was still firmer than that of the cows milk cheese.

Conclusion

Results of this study have shown that sheep milk components do not appear to have any significant inhibitory effect on the potential growth of smear ripening organisms on smear-ripened brick cheese. Growth of yeasts, salt tolerant bacteria, and *Brevibacterium linens* were comparable on cow and sheep milk throughout the aging of brick cheeses processed under equivalent environments. Previous reports of difficulty growing *B. linens* on sheep milk cheeses may have been a result of unfavorable environmental growth conditions. Initial growth of yeasts on the surface of smear-ripened cheeses is critical to use some of the lactate and raise the surface pH to over 6.0 before *B. linens* will start to grow and produce some of the typical pungent, sulfury flavors of smear-ripened cheeses. Bonaiti et al. (2004) reported that when the relative humidity was down to 85%, yeast growth was inhibited due to limitation of carbonyl substrate diffusion; consequently, cheese deacidification did not take place and the *Brevibacterium* could not grow.

Even though we had comparable growth of smear organisms on the surface of both cheeses, the ripening pattern and flavor development of the brick cheeses were not equivalent due to the differences in the casein composition of the milks. Since sheep milk contains a higher proportion of α_{s1} casein, the body of the cheese will be firmer and body breakdown will be slower than comparable cows milk cheeses. Flavor development in smear-ripened sheep milk cheeses may also be slower but over ripening may be less of a problem than with cows milk cheeses. Overall, it appears that there is a real potential for smear-ripened sheep milk cheeses but the aging patterns of those cheeses will be uniquely different than smear-ripened cows milk cheeses.

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Curd Clinic

Curd clinic docs are Bill Wendorff, John Jaeggi and Dean Sommer

Q. I am making some new cheeses and experimenting with aging techniques. I am having some trouble with drying, which produces cracks in the rind. Can you offer a few tips?

A. Let's start by reviewing what happens during the aging process. Essentially, the microbes and enzymes in the fresh curd work together to produce the body, texture and flavor of the finished cheese. Two environmental factors, temperature and relative humidity of the aging room, have a major impact on the growth of the ripening organisms, as well as the activity of enzymes present in the cheese. You have to control these two factors to produce the body and flavor you want in your finished cheese.

Most of the organisms involved in the aging process are mesophilic, which means they grow best at temperatures around 30ºC (86ºF). Although more ripening enzymes are produced at temperatures close to the most favorable growth temperature of the ripening organism, the optimum activities of these enzymes often lie between 45 and 50ºC (Weber and Ramet, 1987). Thus, during the aging of cheeses, ripening temperatures are well below the optimum temperatures for microbial growth and enzyme activity. This is a good thing, it allows chemical changes to take place at a slower and more controllable rate, which opens a wider window for the optimum time to sell your cheese.

Usually, cheese is ripened in aging rooms with less than 100% relative humidity (RH) since it is difficult to saturate the air in a cooled environment. Also, a saturated environment would increase the water activity at the surface of the cheese, allowing undesirable microorganisms to grow. The choice of relative humidity in the aging room will depend on the type of microorganisms you use as ripening agents for your cheese. A high humidity (90-95% RH) is generally used for cheeses with a bacterial surface flora, and a slightly lower RH (85-90%) for those with a fungal flora (Weber and Ramet, 1987). The relative humidity is lowered to 80-85% when aging cheeses with dry rinds, to limit the growth of contaminating organisms on the surface. Some cheeses also require a bit of drying to firm up the body of the cheese and form a protective rind. Thus, RH of the aging environment is critical because it allows a controlled evaporation of moisture from the cheese.

Since temperature and relative humidity in aging rooms are so important and so interrelated, we will evaluate their impact on various types of cheeses.

Mold-ripened soft cheeses

Mold-ripened soft cheeses, e.g., camembert and brie, are generally aged at 10-14ºC (50-56ºF) and 85-93% relative humidity (Masuda et al., 2000; Helilas et al., 2007). In addition to the chemical and physiochemical changes taking place in these cheeses during the early stage of ripening, the cheeses lose weight due to water evaporation and respiratory activity of the microflora. The cheese weight loss is very high (0.2 kg/m^2/day) when RH was 85% but is reduced by half when the RH increases to 92% (Helias et al., 2007). Cheeses, e.g., brie and camembert, that are made in disc shape have a much higher ratio of surface to volume and will lose much more water than a spherical-shaped cheese.

Semisoft cheeses ripened with internal mold

Blue-mold cheeses are generally ripened at lower temperatures of 5-10ºC (41-50ºF) and 85-95% RH (Kandev, 1979; Weber and Ramet, 1987). With these lower temperatures, the proteolysis of casein is slowed but the lipolysis of milkfat is not, thus allowing fat breakdown for flavor development in the blue mold cheeses.

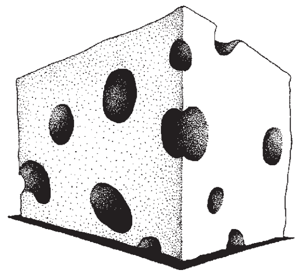
Soft cheeses with washed rind

Washed rind and smear-ripened cheeses are generally ripened at temperatures of 10-15ºC (50-59ºF) and 90-95% RH (Weber and Ramet, 1987). French researchers (Bonaiti et al., 2004; Riaha et al., 2007) carried out experiments on smear-ripened cheeses under nine different combinations of temperature (8, 12, 16ºC) and humidity (85, 93, 99% RH). Bonaiti et al. (2004) reported that regardless of temperature, when the RH was 85%, yeast growth was inhibited due to limitation of carbonyl substrate diffusions. Yeast uses lactic acid to raise the cheese pH to 6.2 and when yeast doesn't grow this doesn't happen and, consequently, the brevibacterium can not grow. Riahi et al. (2007) reported that weight loss during aging was more dependent on the RH than the temperature. Thus, the best ripening conditions to achieve an optimum between deacidification by the yeast and balanced proteolysis by the smear organisms were 12ºC (54ºF) and 95% RH.

Aged semisoft cheeses

For most semisoft cheeses without surface ripening agents, the aging treatment is aimed at controlling or eliminating microbial contamination of the cheese surface. RH above 80% tend to allow softer bodies in the cheeses and growth of contaminating molds on the surface (Surabhi et al., 2007). The optimum aging conditions for semisoft cheeses involve temperatures of 10-14ºC (50-58ºF) and 70-80% RH (Weber and Ramet, 1987; Surabhi et al., 2007).

Aged hard cheeses



Aging hard cheeses can be divided into two different processes. Some, including emmental and baby swiss, are aged at different environmental conditions at different stages of the process. Others, including parmesan, manchego and other hard grating cheeses, are aged in environmental conditions that allow for significant drying of the cheese to reduce the final cheese moisture.

European cheese masters traditionally ripen emmental at 12-14ºC (54-58ºF) for the first two weeks, at 23ºC (73ºF) to completion of eye formation, and at 12ºC thereafter (Fluckiger et al., 1980; Sollberger, 1992). While RHs of 50-72% resulted in drier rinds that were less susceptible to mold spoilage, it did result in greater weight loss in the cheeses. Fluckiger et al. (1980) reported that carbon dioxide (CO_2) pressure increases in cheese with decreasing RH, leading to formation of splits or cracks. Sollberger (1992) stated that sensory panels preferred emmental ripened at 12ºC and 92% RH.

Hard grating cheeses, e.g., parmesan and romano, are aged at lower RH (80% RH maximum) to allow for sufficient drying of the cheese to meet the standards. Hard cheeses are generally aged at temperatures of 10-15ºC (50-5ºF) and RHs of 70-80% (Guidetti et al., 1995; Ruiz et al., 1998). Final aging temperature and RH will depend on the desired rate of drying, in balance with body and flavor development.

In summary, temperature and relative humidity are two critical environmental factors that allow you to control the aging process of natural cheeses. Temperature will tend to influence the growth rate of cultures and secondary microflora in the cheese. However, the relative humidity has a greater effect on growth rate since it influences the water activity (a_w) of the cheese which in turn controls the type of organisms which will grow and produce enzymes during the aging process.

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2008 Wisconsin Master Cheesemaker

"This whole industry has changed so much," says Torkelson. "These days the focus is on the art of cheesemaking."

Tom Torkelson of Pasture Pride Cheese, is a 2008 Wisconsin Master Cheesemaker who admits to being a curious person and passionate about making cheese. As it turns out, that is a particularly useful combination of traits in the world of specialty cheese today.

"This whole industry has changed so much," says Torkelson. "These days the focus is on the art of cheesemaking."

Torkelson grew up on a dairy farm and, as a teen, got farmed out himself to help package cheese at his relative's cheese plants. After high school, he started working at Hay Hollow cheese plant.

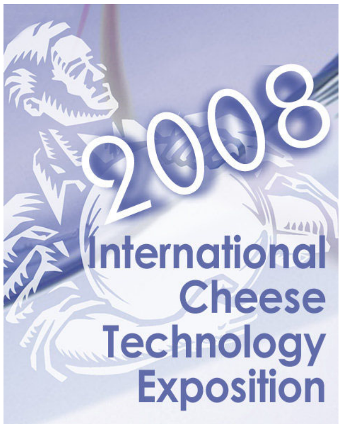
Now, after decades of experience, he admits that making cheese comes pretty natural to him. However, the Master Cheesemaker program added a new layer of knowledge, Torkelson notes that he understands why things happen the way they do in the vat. In addition, the courses he took to fulfill the requirements of a Master Cheesemaker fueled his cheesemaking passion and completing the Master test helped satisfy his curiosity.

Like many of his fellow Masters, Torkelson thrives on the changes and growth in the cheese industry today. For example, he makes award winning mixed milk cheeses and also set up his own washed rind rooms. In addition, Torkelson admits that, "I am really interested in aging techniques."

Another sign of change that Torkelson has seen in the specialty cheese industry is the amount of help and information available. In the past, he notes, you had to search out some primitive recipe in a cheese book and rely on trial and error, figuring out the dos and don'ts yourself. But now, "You can put the cultures together, the milks, do the aging and you can hit a home run with a great product."

Like the cheese industry, Torkelson himself has changed. He used to be very protective of what he was doing, and didn't want anyone to know what he was trying. But now, that has changed admits Torkelson. "I'll drive out of my way to show someone how to do something and I get more excitement from showing them than discovering it myself. It is a good feeling to pass that stuff on." And, perhaps, a good way to encourage and inspire both curiosity and passion.

News from CDR



Cheese Technology Exposition

If you are heading to the 2008 International Cheese Technology Exposition, stop by booth #210 and say hello to CDR staff. Marketing is the focus of the Expo educational sessions this year, the Wednesday morning session will focus on cheese marketing and the Thursday morning session covers whey.

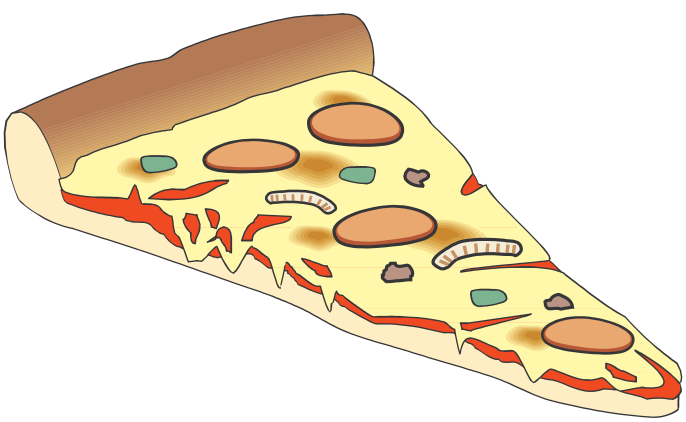
The Expo, at the Alliant Center in Madison,WI runs from April22 to the 24th, for more information see: http://www.wischeesemakersassn.org

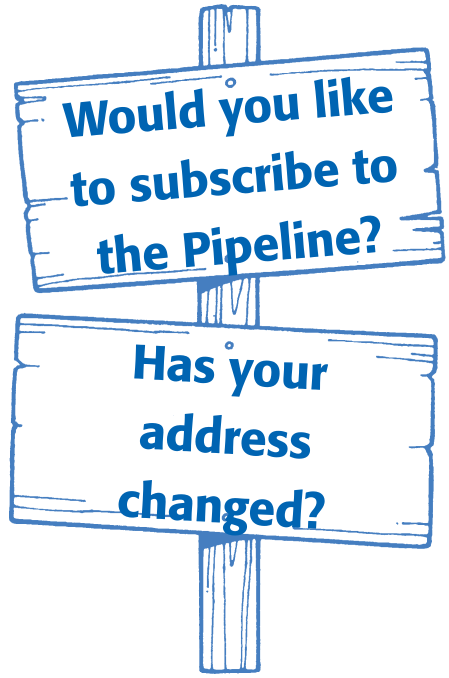
CDR Survey

Conducting a program evaluation survey is just one part of CDR's ongoing strategic planning process, however, it is the part we need your help with. If you receive one, please respond and help us help you!

Recent CDR publications

Use of Cold Microfiltration Retentates Produced with Polymeric Membranes for Standardization of Milks for Manufacture of Pizza Cheese
S. Govindasamy-Lucey, J. J. Jaeggi, M. E. Johnson, T. Wang, and J. A. Lucey. J. Dairy Sci. 2007 90: 4552-4568.





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e-mail: Paulus@cdr.wisc.edu
phone: 608/262-8015

You can also find the Dairy Pipeline on our website: www.cdr.wisc.edu

Calendar

Apr. 22-24 International Cheese Technology Exposition, Madison, WI. For information, call Judy Keller at (608) 828-4550.

May 5-8 The World of Cheese from Pasture to Plate, Madison, WI. Call Dean Sommer at (608) 265-6469.

May 13 Cleaning & Sanitation Workshop, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 14 Dairy HACCP Workshop, Madison, WI. Call Marianne Smukowski at (608) 265-6346.

May 20-21 Applied Dairy Chemistry Short Course, Madison, WI. Call Scott Rankin at (608) 263-2008.

June 3-4 Wisconsin Cheese Grading Short Course, Madison, WI. Call Scott Rankin at (608) 263-2008.

June 28-July 1 IFT Annual Meeting, New Orleans, LA. For information see www.ift.org.

July 7-10 American Dairy Science Association Annual Meeting, Indianapolis, IN. For more information see www.adsa.org.

July 23-27 American Cheese Society Annual Meeting. Chicago, IL. For info, see www.cheesesociety.org.

Aug. 3-6 International Assn. for Food Protection Annual Meeting, Columbus, OH. For information see www.foodprotection.org.

Aug. 5-6 Milk Pasteurization and Process Control School. Madison, WI. Call Scott Rankin at (608) 263-2008 for information, or the CALS Outreach Services (608) 263-1672 to register.

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