College of Agricultural and Life Sciences, University of Wisconsin-Madison ■ Cooperative Extension, University of Wisconsin-Extension

rethinking Dairyland

Background for Decisions about Wisconsin's Dairy Industry

No. 7— July 2004

CAN WE MAKE THE MILK THAT CHEESE MAKERS NEED?

Changing breeds, feeds, genetics and milk quality all influence the mix of fat and protein.

Milk has been described as the perfect food, but to a cheese maker, some milks are more nearly perfect than others. In this edition of Rethinking Dairyland, UW-Madison dairy and food scientists offer their perspectives on how Wisconsin milk can be modified to best meet the needs of the state's cheese industry.

What's the perfect milk for cheese?

The ideal milk for making a whole milk cheese, e.g. Cheddar, would contain 14-15 percent total solids and have a casein-to-fat ratio of about 0.7. Such milk would typically have roughly 4.2 percent fat and 3.6 percent true protein. Few cows naturally produce milk of this composition, so cheese makers usually standardize milk by reducing the butterfat (through cream separation), increasing casein (through vacuum pasteurization) or boosting nonfat milk solids by adding condensed skim milk, nonfat dry milk or ultra-filtered milk concentrate.

Cheese makers need two main milk ingredients: casein and fat. The amount of fat that can be used in making cheese is limited by the amount of casein present to hold the fat in a stable system. Thus, the casein-to-fat ratio is critical in determining a milk supply's cheese making potential. The final composition of a cheese dictates how much casein and fat are required to make that cheese. Table 1 shows ideal casein-to-fat ratios for prominent cheese varieties.

A good target would be a casein-to-fat ratio of 0.70 or a protein-to-fat ratio of .84. This is ideal for Cheddar, Brick, Muenster, Gouda and several other whole-milk cheeses. Milk would then only have to be standardized for other varieties of cheese with fat in the dry matter specifications of less than 50 percent.

A 1997 report found Wisconsin milk was 8.6 percent "deficient" in total protein for cheese manufacturing. This means that the cheese made here contained 8.6 percent more protein than the milk used to produce it. Adding protein, mostly from out-of-state sources made up the deficit. This added protein, amounting to over 50 million pounds of casein, was needed to balance out the surplus fat that cheese plants purchased in the form of producers' milk.

In the past, cheese makers relied on nonfat dry milk, condensed skim milk, or UF liquid milk concentrate to supply the additional casein. More recently, imported milk

THE "IDEAL MILK" DEPENDS ON THE CHEESE BEING MADE.

TABLE 1. Ideal casein-to-fat ratios for selected cheese varieties

Cheese variety	Casein/Fat Ratio	True Protein/Fat ratio[1]
Cheddar	.70	.84
Low Moisture, Part Skim Mozzarella	1.05	1.26
Swiss	.85	1.02
Parmesan	1.10	1.32
Havarti	.60	.72
Brick, Muenster	.70	.84
Gouda	.70	.84

[1] *Assumes casein is .83 times true protein*

This is part of a series of brief reports on the current state of the Wisconsin dairy industry and factors that will influence its evolution. Expanded versions of these reports, with additional data and graphics, are posted online at **http://www.aae.wisc.edu/www/pub/**

If you do not have internet access, copies can be obtained from Ms. Linda Davis, Department of Agricultural and Applied Economics, University of Wisconsin-Madison, 427 Lorch St., Madison, WI 53706. Telephone: (608) 262-9488 or email: davis@aae.wisc.edu

protein concentrate (MPC) has been used as a source of functional casein for standardizing milk for cheese that does not have a Food and Drug Administration (FDA) Standard of Identity.

The protein content of milk varies from month to month. As a rule, milk's fat and protein content drops .2 percent for every 10° F above 70° F. During summer hot spells, Wisconsin cheese makers will see up to a 10-15 percent drop in milk protein and a corresponding drop in cheese yield. Unfortunately, we can't do much about the weather.

How milk differs from state to state

The most comprehensive source of data on milk composition is Federal Milk Marketing Orders, which collect and report composition and quality for all milk "pooled" within orders. Table 2 shows federal order data for the marketing order areas that encompass part or all of the top ten dairy states (except California, which is not included in any federal order).

These data show that Upper Midwest milk has the highest butterfat test among the six orders, more than a point (tenth of one percent) above the lowest-ranked Western order. While protein tests vary less among orders, the Upper Midwest lags the three western orders by .02 to .04 percentage points. Other (nonfat) solids are essentially even across orders, and somatic cell count differs little.

The Dairy Herd Improvement (DHI) program reports average milk composition by state for all herds enrolled in DHI testing. These data allow more direct state-to-state comparisons than do federal marketing order data. DHI data also cover California. However, not all dairy farmers subscribe to DHI testing and those that do tend to use better herd management practices.

Table 3 shows DHI milk composition data for the top ten dairy states. These data represent only a subset of all cows in the DHI program (only cows whose records include sire identification or otherwise qualify for the national genetic evaluation program are represented). The percentages of all cows included in these DHI data are shown in the right-hand column.

The DHI data tell a different story than the federal marketing order data. Butterfat tests in Wisconsin rank high, but are exceeded by Michigan's and tied by New York's and Minnesota's. Wisconsin milk has about .08 percent higher fat content than California's, Wisconsin's chief rival in cheese production.

The DHI data show a larger range of protein percentages among states. Wisconsin is among five states — all of them in the Great Lakes and northeast regions — with protein content just below 3 percent. Protein percentages in western and southwestern states are above 3 percent and range up to

UPPER MIDWEST MILK LEADS IN BUTTERFAT BUT LAGS THE WEST IN PROTEIN

TABLE 2. Characteristics of producer milk by federal milk order marketing area, 2001

Marketing Area	Butterfat percent	True protein percent	Other non-fat solids percent	Somatic cell count 1,000/ml
Upper Midwest	3.72	3.02	5.70	344
Northeast	3.68	3.00	5.69	NA
Mideast	3.68	3.02	5.70	359
Western	3.61	3.06	5.71	NA
Pacific Northwest	3.66	3.04	5.70	NA
Southwest	3.62	3.05	5.67	354

NA — Producer payments are not adjusted for somatic cell count in these markets. Source: Milk Marketing Order Statistics, Agricultural Marketing Service, USDA www.ams.usda.gov/dyfmos/mib/rcpts_milk_ytd.htm

HIGHER-PROTEIN MILK OUT WEST REFLECT PRODUCERS' CHOICES IN BREEDS AND SIRES

TABLE 3. Milk composition for the ten leading dairy states, DHI, 2000-01

State	Rank[2]	Fat	True Protein	Protein breeds[3]	All cows[4]
		percent			
California	1	3.63	3.07	8.0	22.5
Wisconsin	2	3.71	2.99	3.6	16.8
New York	3	3.71	2.98	3.8	24.3
Pennsylvania	4	3.67	2.98	4.4	28.9
Minnesota	5	3.71	2.99	2.4	26.1
Idaho	6	3.62	3.10	10.0	8.5
Texas	7	3.69	3.12	16.4	10.1
Michigan	8	3.80	2.98	3.2	21.0
Washington	9	3.65	3.03	6.1	15.0
New Mexico	10	3.57	3.03	1.5	5.0
U.S.		3.69	3.02	7.0	19.0

[1]Powell, R. L., and A. H. Sanders. 2002. State and national standardized lactation averages by breed for cows calving in 2000. Animal Improvement Programs Laboratory, Agricultural Research Service, USDA http://aipl.arsusda.gov/docs/dhi/current/2.html.

[2]Based on total milk production.

[3]Brown Swiss and Jersey cows as percent of cows among the three leading breeds in the USDA–DHI genetic evaluation program.

[4]Cows of the three leading breeds included in the USDA–DHI genetic evaluation program as percent of all dairy cows in the state.

3.12 percent.

Protein content differs among states partly because a larger share of the cows in western states are high-protein breeds — Jersey and Brown Swiss. (New Mexico is an exception — it has the lowest percentage of Jersey and Brown Swiss but has intermediate protein content). Among Holstein cows in the 10 leading dairy states, protein content is in the 3.03–3.06 percent range in the western and southwestern states and in the 2.96–2.98 percent in the Great Lakes and northeastern states. This suggests that Holstein producers in the western states have emphasized protein more when selecting sires. Protein content of Wisconsin milk lags behind California's by .08 percent protein for all milk and .06 percent for Holstein milk.

These small differences in fat and protein percentage do not mean that Wisconsin milk is inferior for cheese production. Although it is slightly lower in protein content, Wisconsin milk is slightly higher in fat content than is California milk. Using milk from the two states to produce cheddar cheese (without standardization) results in almost exactly the same yield. Nevertheless, there are many opportunities to improve our milk supply.

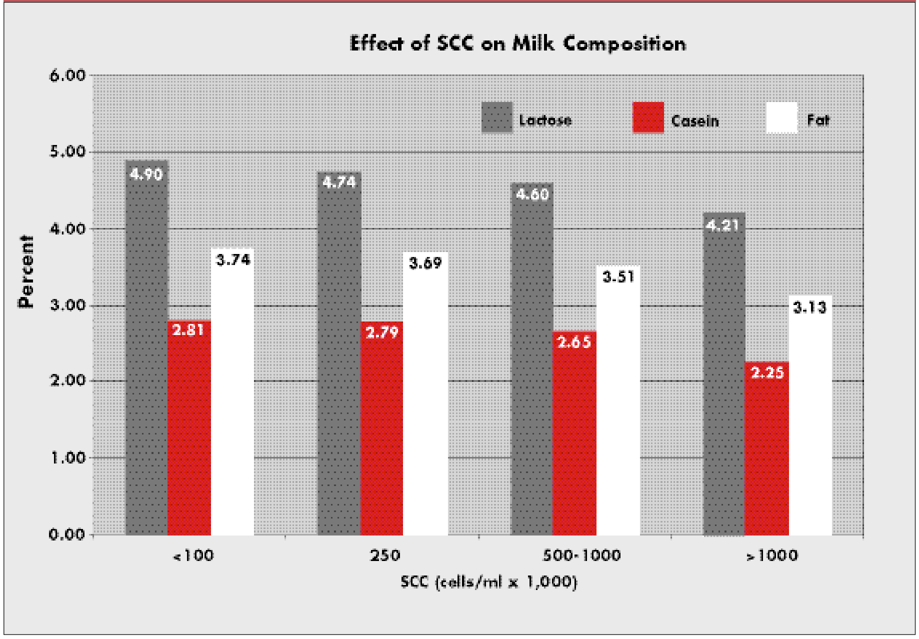
How Wisconsin's milk quality stacks up

The usual measures of milk quality are somatic cell count (SCC) and the bacterial count of pre-pasteurized bulk-tank milk. The key factor in SCC is mastitis. The SCC of a cow not infected with mastitis is usually below 200,000 cells/ml, and many cows maintain SCC values of less than 100,000 cells/ml. A SCC of greater than 200,000 cells/ml is almost always caused by mastitis.

Many processors strongly prefer high quality milk and pay price premiums for it. High SCC diminishes the quality and quantity of milk protein, so that a given volume of such milk will yield less cheese. Even modest increases in SCC (more than 100,000/ml) have been shown to reduce cheese yields (see chart this page). Elevated SCC can also diminish the shelf life and quality of other dairy products.

Milk quality data are available from three of the federal milk marketing orders (see Table 2) and from DHI (Table 4). SCC is reported only for the four milk marketing orders that reward or penalize monthly herd SCC relative to a base of 350,000. Market order SCC reflects all milk in the order area.

MASTITIS IS COSTLY. Even modest bumps in SCC counts hurt cheese yields by diminishing the quantity and quality of milk protein.



The SCC summary from DHI includes only cows whose records are used in the national genetic evaluation program. The SCC from these cows does not differ from cows in DHI herds that are not in the genetic evaluation system, but the SCC in DHI herds in general is lower than for all herds.

Differences in SCC among the milk marketing areas are small. Two milk quality measures are reported from the DHI summary: Average SCC and percent of herd test days with SCC >400,000 cells per ml. The percentage of DHI herds >400,000 is likely higher than the percentage of DHI bulk tanks above the 400,000 cells/ ml threshold — milk from individual cows with high SCC is included in the DHI statistics, but milk from some of these cows is withheld from the bulk tank. Managers of herds with SCC above 400,000 cells/ml need to pay more attention to managing for lower SCC. They're losing money in two ways. They're earning lower milk quality premiums or having milk quality deductions taken from their milk check. And their heavily infected cows are producing significantly less milk.

The state of Washington sets the pace for producing high quality milk. California and Wisconsin are both on the low side for average SCC, but California has a slightly smaller percentage of herds in the undesirable, high SCC ranges. This means that a higher percentage of Wisconsin herds are in need of special attention for improving milk quality. But it is not apparent that, compared to California plants, Wisconsin cheese makers are either disadvantaged or favored in terms of milk quality.

Food safety is another milk quality concern. It's clear that increased sub-clinical mastitis in a dairy herd (indicated by high SCC) could reflect management practices that are associated with reduced food safety. SCC tends to be higher in herds where pathogens that cause food-borne diseases are cultured from bulk tanks. Farms with higher SCC values tend to have inferior herd hygiene practices. Milking facilities, cow housing areas and the udders of cows from herds with higher SCC values have been shown to be dirtier and more soiled with manure. High SCC has also been linked to other indicators of poor milking management. Milk from herds with SCC values above 400,000 cells per ml is 2 to 7 times as likely to contain antibiotic residue that violates local health ordinances than milk from herds with SCC values under 250,000 cells per ml.

Can Wisconsin's milk be improved?

It's important to remember that no cow produces the ideal milk for cheese. The ideal milk for one cheese would not be ideal for another, and fat content relative to casein is higher in milk than in nearly all cheeses. The disparity is small for high-fat varieties such as cheddar, but is magnified for low-fat cheeses like mozzarella. But even though it's not quite attainable, matching casein-to-fat ratios in milk to those in cheese is a goal toward which cheesemakers and farmers should aim. Cheesemakers need to provide the right incentives to promote the right farm practices.

WISCONSIN'S MILK QUALITY IS COMPARABLE TO CALIFORNIA'S

TABLE 4. Milk quality in the top ten dairy states1

State	Somatic Cell Count (1,000 cells/ ml)	Herd test days with SCC >400,000 (percent)
California	298	21.0
Wisconsin	297	25.4
New York	280	22.7
Pennsylvania	317	27.2
Minnesota	420	48.5
Idaho	320	24.7
Texas	342	32.0
Michigan	287	23.4
Washington	275	13.5
New Mexico	311	29.5
US	322	31.1

[1]Miller, R. H., and H. D. Norman. 2002. Somatic cell counts of milk from Dairy Herd Improvement herds during 2001. Animal Improvement Programs Laboratory, Agricultural Research Service, USDA. http://aipl.arsusda.gov/docs/dhi/dhi01/ scc01.htm.

It's also important to remember that protein is the most expensive macronutrient. Protein-rich feeds like soybean meal cost more than high-energy feeds such as shelled corn and forage. The cost of the feed needed to produce a pound of milk protein is twice that of feed needed to produce a pound of of milk fat and four times that needed to produce a pound of lactose. To make protein, a cow must be fed protein-rich feeds. To make milk fat and lactose she needs very little protein from the diet but does require energy-rich feeds. Cheese is a protein-rich food. To increase milk protein levels, the industry needs milk protein payment systems that compensate producers for these higher costs.

Cheese makers see higher returns when milk has higher percentages of components because they can make more cheese per pound of milk. If they want to encourage production of milk with high component levels, they should share those higher returns with producers. In turn, producers should focus on producing pounds of protein and fat rather than percentages of those components. Higher component percentages result in higher prices per hundred pounds of milk, but the size of the milk check depends both on how much milk they shipped and how much fat and protein their milk contains. Multiple component pricing delivers this message clearly, because it expresses milk payments as prices per pound of protein, butterfat, and other solids multiplied by the pounds of these components shipped.

Money talks: Basing premiums on cheese yield or protein sends a clear message

Because raw milk accounts for 85-90 percent of the cost of manufacturing cheese, cheesemakers are extremely interested in milk composition — especially the concentration of fat and casein. With whole milk cheeses, e.g., Cheddar, they are most interested in producing the maximum amount of cheese per pound of milk. With reduced-fat cheeses, e.g., Mozzarella, the cheesemaker must decide if it is more profitable to remove the surplus fat (sell it to creameries for butter production) or to buy additional casein (either NDM or condensed skim milk) to recover the fat in the form of additional cheese. Their decision is determined by prices in the butter and cheese markets.

Premiums are a way for processors to tell producers what they want in milk composition. Producers are very responsive to premiums added to milk prices (premiums for milk with low somatic cell count have probably boosted milk quality more than any other single factor). They are quick to take advantage of any chance to increase revenue and will manage their herds accordingly.

Premiums are often paid to producers based on the volume of milk shipped. Basing the payment system on pounds of cheese or pounds of protein rather than volume would still reward high-volume producers, but it would also encourage production of milk with higher cheese solids content. This strategy would also reward producers with high-protein cattle breeds.

One problem the cheese plants in Wisconsin have had in the past is the structure of the milk pricing system, which is driven by federal milk marketing orders. In the past, this system was geared to needs of the fluid milk market. Prior to January 1996, dairy producers were not paid on a component basis, but rather on a fat-skim milk basis. On average, 60 percent of the value of milk was based on water (volume), 34 percent on butterfat, 2 percent on protein, and 4 percent on other solids.

From 1996 through 1999, the Chicago Regional milk order (which prices most of Wisconsin's Grade A milk) used a multiple component pricing (MCP) system. Under this plan, the average value of protein represented 44 percent of the value of milk, butterfat 34 percent, and other solids 22 percent. In January 2000, this system was further refined when the Chicago order was merged with the Upper Midwest order. Now 58 percent of the value of milk is based on protein, 39 percent on butterfat and 3 percent on other solids.

However, with the fat value being tied to the butter market and protein to the cheese market, sometimes the value of fat can be equal or greater to that of protein. This sends producers mixed signals about the overall value of each of the milk components. If cheese plants want to encourage producers to produce milk with an ideal composition for cheesemaking, they will need to establish a pricing system based on cheese yield that gives farmers consistent signals to produce higher protein milk.

How can farmers produce the milk that cheese plants want?

There are two basic ways that farmers can manage herds to improve the composition of milk for cheese production. Dairy cattle feeding and nutrition can affect milk composition almost immediately. Genetic improvement is the best way to accomplish long-term changes.

Feed for protein

What cows eat affects milk yield, composition and component yields. Multiple-component pricing (MCP) rewards absolute yields (rather than percentages) of fat, protein and other solids. Therefore, a feeding change that increases component percentages but reduces milk yield may or may not increase component yields or gross income depending on the relative magnitudes of change. By the same token, a feeding change that reduced component percentages could still boost income if it increased milk yield. However, a change in diet that increases milk yield while maintaining component percentages will unequivocally increase the yields of all components and gross income.

Because milk contains much less protein than fat, protein is more valuable to cheesemakers. But MCP often pays farmers less for a pound of protein than a pound of fat. This perverse price relationship does not spur producers to increase milk protein percentage or yield, especially if boosting protein reduces fat percentage or yield. Cheese-yield pricing systems aim to send producers the right economic signals.

With grain and byproduct feeds cheap and abundant, dairy farmers have been feeding less forage. In addition, over the last decade, farmers have been feeding cows more corn silage and less alfalfa. Minimum forage diets in which the forage consists of corn silage contribute to high-volume production of milk that is right at the point of fat-test depression. Moreover, while such diets adhere to National Research Council fiber "requirements," they aren't ideal for rumen health. The good news is that these types of diets do, from the standpoint of carbohydrate levels, maximize milk protein percentage and yield.

Three feeding strategies can increase protein beyond what optimal low forage/corn silage diets can achieve. None of them will bring large changes in milk protein content unless the diet is severely unbalanced to start. And even small changes in protein percentage is costly, requiring expensive feed additives.

Forage and Total Mixed Ration (TMR) Par ticle Size. Finely-chopped forages and finely-processed total mixed rations (TMR) can increase milk yield and milk protein percentage, thus also increasing protein yield. But this change lowers milk fat test — often more than enough to drop fat yield despite higher milk production — so whether this practice pays depends on relative protein and fat prices. Also, cows may have digestive problems if the ration lacks enough coarse fiber to maintain chewing activity.

Pursuing this strategy isn't like to significantly increase protein in Wisconsin's milk supply, because many herd managers are already feeding chopped silages with minimal hay in relatively low forage diets. But many individual producers could benefit from adopting this practice.

Supplemental Fat. Dairy farmers often supplement milking rations with 1 to 2 pounds per cow per day of added fat. This can boost milk yield — by about 3–4 pounds per pound of added fat — and also improves body condition and fertility.

SIRE SELECTION INDEXES SHOW THAT SELECTING FOR PROTEIN PERCENT OR PROTEIN/FAT RATIO CAN SUBSTANTIALLY REDUCE A COW'S LIFETIME PROFITS

TABLE 5. Average Predicted Transmitting Ability of the top 100 Holstein bulls when selection is based on various traits, and average of all active AI Holstein bulls [August 2002 data].

	Average Predicted Transmitting Ability								
Selection Trait	Milk (lbs.)	Fat		Protein		Protein/Fat Ratio	Cheese Merit	Net Merit	Fluid Merit
		(lbs.)	(%)	(lbs.)	(%)				
Protein (lbs)	1,960	57	–.05	62	.015	.017	$501	$491	$473
Protein percent	857	42	.05	43	.073	.010	402	371	253
Prot: Fat Ratio	1,564	19	–.15	47	.005	.037	364	359	358
Cheese Merit $	1,695	59	–.10	57	.029	.010	535	520	478
Net Merit $	1,776	60	–.02	58	.020	.010	533	521	495
Fluid Merit $	2,000	55	–.07	54	–.020	.010	484	489	535
All AI Bulls	1,230	38	–.03	38	.009	.009	345	339	330

For reasons that aren't well understood, when the supplemental fat consists of whole oilseeds, milk protein percentage falls about 0.1 percent per pound of added fat while milk fat test is not altered appreciably. Despite the drop in protein, it still pays farmers to add fat to the diet as long as the value of the additional protein and milk fat exceeds the cost of supplemental fat. But these benefits come at a cost to cheesemakers, who need to add more protein to their cheese vat to achieve optimal casein-to-fat ratios. If farmers quit feeding fat, cheesemakers could capture an extra 0.10 to 0.20 percentage points of milk protein at the same milk fat percentage. Still, dairy producers are usually better off feeding supplementary fat.

Dietary Protein. Underfeeding dietary protein makes no economic sense, especially when protein supplement prices are low. Underfeeding protein reduces milk yield and milk protein percentage and yield. Overfeeding dietary protein doesn't make sense either — from an economic or environmental standpoint. It doesn't increase milk yield or milk protein percentage or yield.

Formulating dairy cattle diets for amino acid balance is an idea whose time has not yet come. With current methods and relative farm-level prices for protein and milk fat, costs exceed benefits. Amino acid supplements are costly. Higher protein prices would likely stimulate more research that could make amino acid supplementation pay.

Genetic changes

There are two ways to change milk composition by breeding: selecting sires within a breed, and changing breed composition of the dairy cow population. We'll look at this from a national perspective, because breed improvement programs, genetic evaluation of animals, and semen distribution are all conducted nationally.

Sire selection. Improved genetics accounts for about half of the annual increase in U.S. per-cow milk production, and more than 90 percent of genetic improvement is due to sire selection. Within a breed, using better bulls offers the greatest opportunity for changing milk composition.

How much would we increase the value of milk by altering its composition through breeding? To find out, we can look at the capability of sires to transmit high-component yields and percentages. USDA's Animal Improvement Programs Laboratory (AIPL) uses Dairy Herd Improvement records to compute genetic evaluations of bulls and their daughters. The measure of genetic merit is called Predicted Transmitting Ability (PTA). The difference between the PTAs of two bulls is a prediction of the difference in performance of their future daughters.

AIPL develops selection indexes to identify bulls whose daughters are expected to be most profitable. A bull's index value predicts the milking lifetime net income over feed and health costs for an average daughter when the bull is mated to a breed-average cow. Of course, milk income depends on who buys the milk. So the AIPL publishes three selection indexes corresponding to the value of milk in making cheese (Cheese Merit), fluid milk products (Fluid Merit), and a combination of products (Net Merit). These indexes differ with respect to the relative prices assigned to protein and milk volume in calculating lifetime income.

Which index to use depends on what the producer gets paid per pound of protein. The Cheese Merit index is recommended at protein prices above $2.85/ lb. At protein prices below $1.25/ lb the Fluid Merit index is most appropriate. The Net Merit index is best for intermediate protein prices. During the 36 months of 2000 – 2002, the federal order protein price fell below $1.25/ lb for only two months, and it never exceeded $2.70/ pound. Therefore, producers should choose sires using the Net Merit index. Protein prices would need to run consistently at least $1.00 to 1.25/ lb higher than they have during the past three years to make the cheese merit index an appropriate sire selection criterion.

The average Predicted Transmitting Abilities for various groups of Holstein AI bulls available in fall 2002 are shown in Table 5. Values in the first six rows are the average PTAs of the top 100 bulls chosen on the trait shown in the first column of the table. The last row is the average of all 649 active AI bulls; this serves as a benchmark for comparison for the groups of top 100 bulls shown in the previous rows.

Comparisons between rows indicate the expected differences in daughter performance for the different bull selection criteria. For example, compare the rows Protein (lbs) and Protein (%): Daughters of the top 100 bulls selected for protein yield will produce, on average, 1103 lbs more milk, 19 lbs more protein, and $120 more lifetime net merit, than daughters of the top 100 bulls selected for protein percent.

The table supports these conclusions:

- Selecting bulls using the Cheese Merit index or the Net Merit index produces the highest returns in lifetime profit per animal. The two are essentially equivalent in lifetime profit whether producer payment for protein is similar to that assumed for net merit or cheese merit. Cheese Merit provides slightly more gain in protein percentage; this is due to a lower response in milk yield rather than a higher response in protein yield.
- Selecting bulls using the Fluid Merit index is inappropriate for a cheese market. This results in substantially lower lifetime profit per animal (compared to Cheese Merit and Net Merit), and lower fat and protein percentages.
- Selecting bulls strictly on protein percent produces the greatest gain in that trait but results in substantially lower yields of milk, fat and protein and lower lifetime profit per animal.
- Selecting bulls for protein/fat ratio yields the greatest improvement in protein/fat ratio but the least in lifetime profit per animal. The high ratios are accomplished more by selecting for low fat yields and percentages than by attaining high protein yields and percentages.

There's a limit to how much a producer can improve milk composition through breeding, because there are strong biological associations among milk traits. For example, bulls with high predicted transmitting ability (PTA) for protein percent also tend to have high PTA for fat percent. Very few bulls transmit high protein percent along with low fat percent. As a result, breeding cattle with high protein to fat ratios is practically impossible. Progress toward such a goal would be slow and not economically viable.

The association between protein percent and milk yield is moderately negative — bulls with high PTA for protein percent tend to have low values for milk yield. This makes it difficult to simultaneously increase milk production and protein percentage.

Breed selection and crossbreeding. The fastest way to change milk composition through genetics is to change breed composition in commercial dairy herds — crossbreeding. (Producers of registered cattle should continue pure breeding in order to continue genetic improvement of the breeds. But only 15 percent of herds have registered cattle).

Crossbreeding capitalizes on the strengths of two or more breeds and offers the advantage of hybrid vigor. Dairy is the only livestock industry that does not exploit the genetic phenomenon of hybrid vigor. Many herds contain cows of two breeds, but rarely do these mixed herds produce crossbred animals.

More than 95 percent of Wisconsin dairy cows are Holsteins. A logical way to change the breed composition of the Wisconsin dairy herd would be to breed Holstein cows to Brown Swiss or Jersey bulls. In producing milk for cheese manufacture, the principal advantages of the Holstein are high yields of milk, fat, and protein per cow and the comparatively high ratio of casein to fat. The Jersey breed has the highest protein and fat percentages, but the lowest casein to fat ratio and lowest component yields per cow.

To understand the benefits of crossbreeding, let's imagine two equal-sized herds, one a crossbred herd derived from two breeds, the other divided half-and-half between purebred cows of the same two breeds. Both herds would produce the average milk yield and composition of the two pure breeds. But the crossbred herd would have hybrid vigor, which would boost its milk and component yields by about 5 to 6 percent (measured by weight). Hybrid vigor wouldn't change milk component percentages much. But it would boost survival, herd life, lifetime production, and lifetime net return by 15 to 20 percent above the average of the purebreds.

CROSSBRED HERDS' HYBRID VIGOR WOULD BOOST MILK AND COMPONENT YIELDS BY 5–6 PERCENT

TABLE 6. A theoretical comparison of half-and-half purebred herds with crossbred herds for Holstein-Jersey and Holstein-Brown Swiss breed combinations [1]

Breed Composition	Milk	Fat		Protein		Casein	Casein/Fat Ratio
	lbs	lbs.	%	lbs.	%	%	
Holstein	24,417	893	3.64	733	3.00	2.49	.680
Brown Swiss	20,300	814	4.01	672	3.31	2.75	.690
Jersey	17,038	784	4.60	610	3.58	2.97	.650
.5H + .5J	20,777	838	4.03	672	3.23	2.68	.665
H x J cross	21,816	880	4.03	705	3.23	2.68	.665
.5H + .5BS	22,408	854	3.81	702	3.13	2.60	.682
H x BS cross	23,529	896	3.81	738	3.14	2.60	.684

[1]Based on the US breed averages. Breed cross averages assume hybrid vigor is 5 percent for yield traits and 0 for percentage traits.

Table 6 shows a hypothetical comparison of lactation production between two such herds. Calculations assume 5 percent hybrid vigor and are based on the U.S. breed averages shown in the first three rows of the table.

The results show the crossbred herd's clear advantage. In most cases the crossbred will not exceed Holsteins for lactation production. However, taking into account improvements in fertility, herd life, and lifetime yield, the profitability of crossbreds may often equal or exceed purebred Holsteins. (Whether crossbreeding pays for an individual producer depends on milk markets and other factors).

The other thing cheese makers need

Clearly, improving the composition and quality of Wisconsin's milk is key to keeping the state's cheese industry strong and profitable. But any conversation about meeting the cheesemakers' needs has to deal with one measure that's easiest to comprehend: quantity.

Wisconsin's shrinking milk supply has left cheese plants operating below full capacity, which has driven their costs above those of rivals in regions where milk is abundant.

There are two ways to increase milk production: milk more cows and increase production per cow. The number of cows is determined by economic and social factors, so let's consider how we can we get more milk out of the cows we have.

Among the top ten dairy states, Wisconsin ranked 9th in milk per cow in 2001, 900 pounds less than the national average. Not all Wisconsin herds are so far below average. Wisconsin's DHI herds are near the U.S. average, and nearly 10 percent of these produce more than 25,000 lbs milk per cow per year, putting them among leading herds anywhere. Milk quality is substantially better in higher producing herds, which underscores the point that high-producing herds are better managed in virtually every respect.

On the down side, milk from higher producing herds has lower fat and protein percent. Individual cows, sire daughter groups and herds with higher milk yield all tend to have lower milk composition percentages. But pounds of milk components and the cheese derived from those components are higher. In addition, casein/fat ratio increases with milk yield because fat percent decreases faster than protein percent as milk production increases.

A herd averaging 28,000 lbs per cow per year has clear advantages over one averaging 14,000 lbs. Most obvious, it takes half as many cows to produce the same amount of milk. The higher producing herd uses more feed and labor per cow, but total feed and labor costs are less because fewer cows produce the same amount of milk. Housing and milking costs per hundredweight are also lower.

Farmers are often advised to boost herd size when they could generate greater returns by increasing production per cow. Such producers should focus on improving fundamental cow management before increasing herd size.

While high production per cow is consistent with other measures of efficiency, it is not by itself an adequate measure. There's no optimal production per cow. A better measure is cost of production per hundredweight of milk. In Wisconsin, an even better measure would be cost per pound of cheese, which works across all breeds of cows and production systems.

This factsheet is based on Marketing and Policy Briefing Paper 78e. For information on obtaining copies, see p. 1. This factsheet was written by Professors George Shook, Randy Shaver and Pamela Ruegg of the Department of Dairy Science and William Wendorff of the Department of Food Science, College of Agricultural and Life Sciences, University of Wisconsin-Madison. Please direct questions and comments to George Shook at (608) 263-3486 or geshook@wisc.edu.