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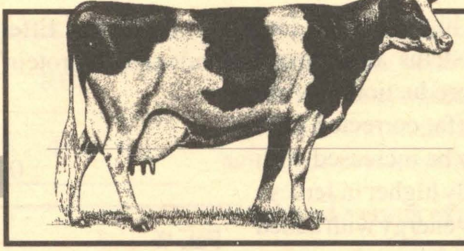

Nutrition Changes Milk Composition

*Charles C. Stallings**

There are many things that can affect milk composition. Environment, breed, and nutrition are three that come readily to mind. Every summer we see a reduction in milk, fat and protein concentration as a result of hot weather. Usually the average fat percent of cows on DHI in Virginia drops from approximately 3.7% in March to 3.4% in August. Protein drops from 3.2% to 3.1%. Generally, milk protein will not fluctuate as much as milk fat. Breed will also affect milk composition (Table 1). Total solids of milk produced by Holstein cows in a recent experiment averaged 12.4% versus 14.6% for Jerseys. Holsteins produced less milk fat (3.7% vs. 5.1%), solids-not-fat (8.7% vs. 9.5%), and protein (3.1% vs. 3.7%). Lactose and other components (mainly minerals) did not tend to be drastically different.

Table 1. Milk composition of Holstein and Jersey cows at Virginia Tech.

	Holstein	Jersey
Total solids, %	12.4	14.6
Fat, %	3.7	5.1
Solids-not-fat, %	8.7	9.5
Protein, %	3.1	3.7
Lactose, %	4.9	5.0
Other, %	.7	.8

Nonstructural carbohydrates (NSC) and fiber

When we increase nonstructural carbohydrates (NSC) concentration of a ration we increase starch by feeding more grains, thus reducing the amount of fiber. Table 2 is from a study by Ireland-Perry and Stallings (1993) with diets containing 17% acid detergent fiber (65% starch) and 25% fiber (53% starch). Dry matter intake and milk production were reduced with higher fiber, lower starch diets. This reduction in milk was observed even when standardized to 4% fat. Milk fat concentration increased from 3.36% to 3.69% by increasing fiber from 17% to 25% ADF. Milk protein concentration did not change; however, there was a trend of less percent protein with the higher fiber ration. This trend is consistent with observations where milk protein increases as energy consumed increases and vice versa. The 17% fiber ration was higher in energy than the 25% fiber ration.

Table 2. Effect of ration fiber and starch on intake, milk production, and milk components.

	ADF		
	17%	25%	Sign.
Dry matter intake, lbs./day	41.4	36.7	*
Milk production, lbs./day	54.6	47.5	*
4% fat corrected milk, lbs./day	49.1	45.3	*
Fat, %	3.36	3.69	*
Protein, %	3.22	3.11	NS

** = significant difference, NS = not significant*

Rumen resistant fat and rumen undegraded protein (RUP)

Fat and protein have been found to be more efficiently utilized if they are resistant to degradation in the rumen. In Tables 3, 4, and 5 are results from a study conducted at Virginia Tech (Rodriguez et al, 1997) comparing two levels of RUP (29% and 41% of total protein) and addition of rumen resistant fat (2.7% as Ca soaps of fatty acids). Diets consisted (% of dry matter) of 30% corn silage, 29% alfalfa silage, and varying levels of shelled corn. Blood meal

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replaced some soybean meal in diets high in RUP. Dry matter intake was reduced in both Holsteins and Jerseys when additional fat was fed, but milk production was increased. Efficiency of milk production (fat corrected milk per Mcal of energy consumed) tended to be increased with added fat in Holsteins and was significantly higher in Jerseys indicating improved conversion of dietary energy with added fat. The Jerseys used in this study did have a greater efficiency of energy conversion than Holsteins. There were no differences in intake, production, or efficiency with differing RUP levels for either breed.

Table 3. Effect of feeding rumen resistant fat and undegraded protein (RUP) on intake and production.

	Fat			RUP		
	0%	2.7%	Sign.	29%	41%	Sign.
Dry matter intake, lb/day						
Holstein	50.9	48.0	*	49.7	49.2	NS
Jersey	39.5	37.1	*	38.6	38.0	NS
Milk production, lb/day						
Holstein	72.1	77.0	*	73.8	75.2	NS
Jersey	49.7	53.4	*	51.2	51.9	NS
Fat corrected milk per Mcal NE, lbs.						
Holstein	1.94	1.99	NS	1.94	1.99	NS
Jersey	2.07	2.27	*	2.16	2.18	NS

** = significant difference, NS = not significant*

Table 4 contains milk components. Feeding rumen resistant fat did reduce fat percent in Holsteins but not Jerseys. When feeding fat, protein percent was reduced in both breeds, and casein was reduced in Holsteins but not Jerseys. Casein is the largest component of the protein in milk. Milk urea nitrogen was increased with added fat in Jerseys but not Holsteins. Level of RUP did not have an effect on fat percent. The highest level of RUP (41%) did result in a reduction in protein percent in both breeds, perhaps indicating a reduced supply of amino acids for milk protein synthesis. This was an unexpected observation because other studies have indicated either no change or increased milk protein when rumen resistant protein is fed. Casein was reduced in Jerseys but not Holsteins with higher RUP and milk urea nitrogen was increased in both breeds. Results of this study might indicate that RUP above 40% is undesirable from a milk protein standpoint and a more moderate level would be best.

Table 4. Effect of feeding rumen resistant fat and undegraded protein (RUP) on milk components.

	Fat			RUP		
	0%	2.7%	Sign.	29%	41%	Sign.
Fat, %						
Holstein	3.80	3.58	*	3.64	3.74	NS
Jersey	5.10	5.09	NS	5.09	5.10	NS
Solids–not-fat, %						
Holstein	8.77	8.55	*	8.70	8.62	NS
Jersey	9.60	9.37	*	9.53	9.45	NS
Protein, %						
Holstein	3.17	2.97	*	3.14	3.00	*
Jersey	3.88	3.58	*	3.80	3.66	*
Casein N, % of total N						
Holstein	75.3	74.6	*	75.1	74.8	NS
Jersey	77.7	77.4	NS	78.0	77.1	*
Urea N, % of total N						
Holstein	5.01	5.15	NS	4.82	5.34	*
Jersey	3.59	3.87	*	3.63	3.83	*

** = significant difference, NS = not significant*

All the short chain fatty acids were reduced by added fat in both breeds but only $C_{14:0}$ is shown (Table 5). There were no changes in the $C_{16:0}$ for either breed. The long chain fatty acids, $C_{18:0}$ and $C_{18:1}$, were increased with added fat. Short chain fatty acids come from synthesis in the mammary gland while long chain comes from either the diet or adipose tissue breakdown. Therefore, the increase in long chain fatty acids is likely a result of the diet supplying fatty acids for milk fat synthesis at the expense of production of the short chain fatty acids. This observation is consistent with what was expected. Level of RUP had no consistent impact on milk fatty acid content.

Rumen resistant amino acids

Table 6 (Pisulewski et al, 1996) demonstrates the impact of supplying methionine (potentially the first limiting amino acid) to lactating dairy cows. No impact on milk production or milk fat percent was observed. Milk protein and casein did increase with increasing amounts of amino acid, indicating increased protein synthesis in the mammary gland due to more methionine being available. Milk non-protein nitro-

Table 5. Concentration (% of total) of fatty acids in milk fat.

	Fat			RUP		
	0%	2.7%	Sign.	29%	41%	Sign.
$C_{14:0}$						
Holstein	12.1	9.4	*	10.8	10.7	NS
Jersey	12.9	10.7	*	11.7	11.9	NS
$C_{16:0}$						
Holstein	43.3	42.6	NS	42.6	43.3	NS
Jersey	45.4	44.6	NS	45.0	45.0	NS
$C_{18:0}$						
Holstein	8.4	9.1	*	8.8	8.7	NS
Jersey	9.0	10.1	*	9.8	9.4	NS
$C_{18:1}$						
Holstein	19.0	24.7	*	21.9	21.8	NS
Jersey	15.1	19.7	*	17.4	17.4	NS

** = significant difference, NS = not significant*

gen was not affected. This study indicates that supplying limiting amino acids will increase milk protein synthesis under certain conditions; however, the response is variable. There are commercial sources of rumen protected amino acids, but cost:benefit ratios should be analyzed.

Observed versus expected responses

In Table 7, I have combined our observed responses to give an overview of the effect of diet change on milk components. Also parentheses ( ) were used when no observations were reported or the response differed from what we observed. For instance, the table shows that milk fat decreased when NSC or starch was greatest and increased when fiber was highest. There were no observations on chain length of fatty acids, but I would expect the short chain fatty acids to decrease with increasing NSC and increase with increasing fiber. Long chain fatty acids would not be expected to be changed. Milk protein was not changed in our reported study, but we would expect NSC to increase and fiber to decrease protein content. Also, casein would be expected to be increased by NSC and reduced by higher fiber. Milk urea would not be expected to be changed by NSC or fiber. Many of these alterations are a result of changes in rumen fermentation. Higher NSC would result in greater acid production and a reduced acetate:propionate ratio. Fiber, however, would cause a natural buffering resulting in an increased acetate:propionate ratio. Higher acetate:propionate ratio is related to greater milk fat production. Milk protein percent responds to greater energy intake, probably indicating increased energy for protein synthesis.

Resistant fat resulted in reduced milk fat only in Holsteins. Many reports have indicated no change in fat percent when fats are fed and some have indicated an increase. We observed a decrease in short chain fatty acids and an increase in long chain, as expected. Also as expected, we observed reduced milk protein and casein when feeding resistant fat.Milk urea was increased.

Table 6. Effect of infused methionine on milk production and composition.

	Methionine, g/d					
	0	6	12	18	24	Sign.
Milk production lbs./day	82.5	83.4	79.9	80.5	81.6	NS
Milk fat, %	3.44	3.45	3.38	3.43	3.48	NS
Milk true protein, %	2.72	2.76	2.86	2.94	2.97	*
Milk casein, %	2.27	2.31	2.38	2.49	2.52	*
Milk NPN, %	.028	.030	.028	.027	.030	NS

** = significant difference, NS = not significant*

Table 7. Observed and expected responses ( ) of milk components to dietary nonstructural carbohydrates (NSC), fiber, rumen resistant fat, rumen undegraded protein (RUP), and protected amino acids.

	NSC	Fiber	Resistant Fat	RUP	Protected AA
Milk fat, %	↓	↑	↓(0)	0	0
Short Chain	(↓)	(↑)	↓	0	↑
Long chain	(0)	(0)	↑	0	0
Milk protein, %	0(↑)	0(↓)	↓	↓(↑)	↑
Casein	(↑)	(↓)	↓	↓(↑)	↑
Urea	(0)	(0)	↑	↑(↓)	0

Observations with feeding RUP differ from other reports and from what we expected. There were no changes in milk fat, short chain fatty acids, or long chain fatty acids when greater RUP was fed. However, milk protein and casein were reduced contrary to expectations. Also, an unexpected increase was observed in milk urea. Perhaps with high levels of RUP we are limiting microbial protein production in the rumen and consequently limiting amino acids needed for protein synthesis. We were feeding approximately 1.6 lbs./cow/day of blood meal, more than is typically recommended (1 lb./day maximum). A more typical amount would likely have had a different result with respect to milk protein.

Rumen protected amino acids are relatively new and there are questions about their effectiveness and cost. The quoted study demonstrated that infused methionine did not change fat percent, but did increase short chain fatty acids but not long chain. Milk protein and casein were elevated, indicating the need for this amino acid for milk protein synthesis. Response may not always be predictable, however.

Practical feeding suggestions

1. Feed a combination of NSC and coarse fiber to maximize dry matter intake and provide rumen available energy for microbial cell production plus adequate amount for rumination, chewing, and saliva production (sodium bicarbonate). Another rule is to feed between .9% and 1% of body weight as forage neutral detergent fiber. While levels of NSC are not well defined, nonfiber carbohydrates [100-(NDF + Protein + Fat + Ash)] would normally be between 34% to 40% of ration dry matter and acid detergent fiber would be 18% to 21%. High moisture grains and fine grinding may increase the rapidity of starch availability in the rumen (may or may not be a benefit).

2. Fats can change feeding patterns and should be introduced slowly at reduced rates. Some change in milk composition is to be expected, especially protein. However, yield of protein should be the same because of increased milk production. Whole seeds (soybean and cottonseed) many times are good, economical sources of at least part of the supplemental fat. Do not exceed 7% of the ration dry matter as fat.

3. Avoid extremes in amount of RUP in rations. Indications are that levels in excess of 40% should be avoided. Probably 35% to 38% of the total protein as RUP is desirable for higher producers. Observe the established maximums for blood meal (1 lb./cow/day), fish meal (1 lb.), roasted soybeans (7 lbs.), and distillers grains (7 lbs.). Also, remember that excess protein degradability can be bad. Urea for instance should not be fed at greater than .4 lbs./cow/day and limits should be placed on using wet alfalfa silage and ammoniated corn silage. In other words, balance the rumen degradable and undegradable protein.

4. Feeding blends of proteins with different amino acid profiles might be of benefit. Avoid situations where corn silage is fed along with corn grain and corn by-product feeds such as corn gluten feed and distillers grains. Commercial protected amino acids may give an increase in milk protein production, but it must be an economical one to justify use.

5. Feed additives such as sodium bicarbonate and yeast may have a benefit by maintaining or increasing milk fat percent. Sodium bicarbonate at .3 to .5 lbs/cow/day is recommended when feeding high amounts of NSC. Yeast may work better on higher forage diets to increase ruminal fiber digestion. These additives are most economical if targeted to fresh and high producing cow groups.

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