ECONOMIC IMPLICATIONS OF CHANGING MILK COMPOSITION WITH NUTRITION

by

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Since the development of the Babcock fat test 100 years ago, milk has been bought and sold largely on the basis of its fat content. With the continued decrease in market value of milk fat and the large surplus of butter, milk marketing organizations are attempting to change payment of milk to true market values for milk fluid and its constituent nutrients. Consequently, it is important to understand the biological variation that exists in milk composition, what causes this variation, and how we might change composition in the desired direction. An approximate average composition of farm-produced milk in the U.S. is shown in Table 1 (right-hand column). Data are from analyses of Dr. D. M. Barbano who surveyed monthly the composition of milks received at 50 cheese plants located in 19 different states during 1984.

Fat percentage of milk is the most variable and most widely measured constituent since payment traditionally has been based on fat content. Measurement of fat has served the marketing, breeding, and feeding phases of the dairy industry well since variation in fat content is associated consistently enough with variation in other constituents to allow prediction of the change in these constituents that would accompany a change in fat content. For example, seasonal variation in milk composition is conspicuous. Data in Table 1 show low fat percentages in summer and high values in winter. Milk protein percentages vary in the same direction but the relative change is much smaller. The crude protein percentage was calculated by measuring total nitrogen content of milk and multiplying it by 6.38. Milk protein contains 15.67% N in contrast to the 16.0% assumed for most proteins for which crude protein is calculated by multiplying N x 6.25. True protein content of milk is usually 95 percent of crude protein and casein is about 82 percent of true protein (Table 1).

Table 1. Seasonal variation in milk composition.

Milk constituent	Month of the year or yearly average					
	Jan	Mar	May	July	Sept	Nov	Ave.
Fat	3.87	3.65	3.50	3.40	3.60	3.78	3.61
Crude protein	3.34	3.27	3.20	3.13	3.29	3.38	3.27
True protein	3.19	3.12	3.04	2.97	3.12	3.23	3.11
Casein	2.62	2.56	2.49	2.43	2.56	2.65	2.56
Solids-not-fat	8.77	8.72	8.72	8.56	8.60	8.77	8.68
Lactose	4.55	4.52	4.55	4.49	4.47	4.59	4.54
Ash	.71	.70	.71	.72	.73	.75	.72
Total solids	12.47	12.14	11.96	11.74	12.09	12.50	12.14
Water	87.53	87.86	88.04	88.26	87.91	87.50	87.86

Source: Barbano, 1990.

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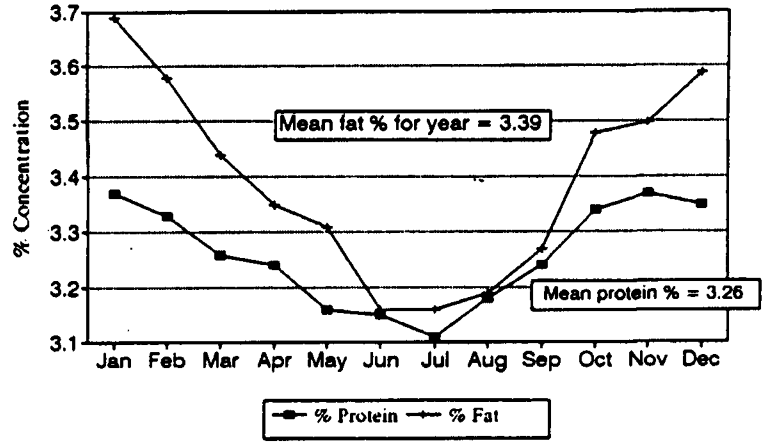
The above data also show that variations in lactose and ash are quite small. Thus, variation in SNF (crude protein + lactose + minerals) primarily is due to variation in milk protein content.

Figure 1. Effect of Season of Year on Milk Composition in Southern Region



Although regional differences existed in source data used for Table 1, the noted seasonal variation was very similar regardless of region. Main regional differences involved milk fat percent which was lowest in the South (3.39%) and milk protein percent which was lower in the Northeast and South (3.22 and 3.26%). Seasonal changes in milk fat and milk protein percent for the South (Arizona to Virginia to Florida) are shown in Figure 1. The mean protein percent for Florida milk is probably even lower than the 3.26% mean for the Southern Region based upon the 1990 lactation average of 3.11% for Holsteins enrolled in the Florida DHIA. This value should be a good predictor of the overall state average since 94% of the completed lactations were from Holsteins.

Changing Milk Composition Through Genetics

Changing milk composition through animal selection is possible. Despite the appearance that milk pricing formulas pay on percent composition, yields of milk fluid and of solid nutrients determine pay. For example, a base price of $13.50 for 3.5% milk with a fat differential of $.10 for each change of .1% in fat indicates that 100 pounds of milk fluid without any fat is worth $13.50 minus (35 x $.10) or $10.00. The 3.5 pounds of fat is worth $3.50 to the dairyman. A differential for milk protein could be included also. Thus, a dairyman should select for the yield of those constituents that are of most economic value to him. The genetic correlations between milk yield and yields of fat and protein are very high (> than .80) as is the genetic correlation between yield of protein and yield of fat. Animal factors which control yield traits are so closely related that yield of milk fluid, fat, or protein can not be increased without causing a simultaneous increase in the yields of the other two. If selection emphasis were placed on milk composition instead of yield, it would be possible to change composition but milk yield might be depressed considerably because negative genetic correlations exist between yields and percentages of each milk solid constituent (Wilcox, et al., 1971).

In summary, yield and percentage traits for milk and milk components are so highly correlated that even a penalty for fat production will not be an economic incentive for dairymen to select for higher milk protein or SNF percentages in preference to higher yields of milk protein and SNF. This is not to say that dairymen should not be aware of the transmitting ability of bulls to raise or lower milk protein percent in addition to their ability to increase the dollar value of milk yield in their offspring and select bulls for increases in milk protein percent and milk fat percent after yield criteria are satisified.

<u>Changing Milk Fat Concentration Through Nutrition</u>

Avoidance of depression in milk fat percent is the usual thrust of materials written on this subject. Factors affecting milk fat percent have been studied extensively and are known to influence the endproducts of rumen fermentation--primarily the proportions of acetic, propionic, and butyric acids. Milk fat is produced within the mammary gland from preformed fat of dietary and adipose tissue origin as well as from fatty acids produced with the mammary gland. Each source contributes about 50% of the total milk fat produced. The mammary gland requires a source of two-carbon units for fatty acid synthesis which it primarily derives from the acetic and butyric acid endproducts of rumen fermentation. Acetic acid absorbed from the rumen is the primary precursor of short-chain milk fatty acids (4 to 14 carbons) produced in the mammary gland. The longer chain fatty acids except palmitic acid generally are transferred from the blood to milk and are not synthesized in the mammary gland.

Propionate, which is more efficiently converted to blood glucose and used for production of lactose and metabolic energy, is not used extensively for milk fat synthesis. In fact, dietary changes which bring about reduced acetic acid and increased propionic acid production are associated with milk fat depression. Diets relatively high in fiber encourage growth of microorganisms in the rumen which produce primarily acetic acid. The fibrous components within the diet stimulate through added chewing and rumination the production of saliva which buffers the rumen environment to higher a pH (above 6.0) at which fiber digesting organisms grow best.

Feed additive buffers such as sodium bicarbonate are often fed with diets that would otherwise produce more rumen acidity (pH below 6.0) in order to retain the more optimum conditions for production of acetic acid and thereby maintain a higher milk fat percent. High starch diets and finely ground diets which require very little chewing and rumination produce a rumen environment which is more acid thereby favoring organisms that produce propionic acid. For body weight gain and milk nutrients other than milk fat, greater metabolic efficiency may be obtained from fermentations that produce more propionic acid.

Feeding highly unsaturated fats or fatty acids which release significant amounts of unsaturated fatty acids in the rumen can reduce milk fat percent, presumably through negative effects on acetate producing microorganisms in the rumen. Ionophores (e.g., Lasalocid and Rumensin) are not approved for feeding to lactating cows but would reduce milk fat percent, if fed, by inhibiting acetate-producing microorganism.

If economic incentives existed which favored production of milk with lower milk fat percent, management practices that are used currently could be modifies or reversed. For example, we could feed less fiber or grind it finer, discontinue feeding buffers, feed more unsaturated fatty acids, process high starch ingredients to encourage more propionate production, consider feeding ionophores, etc. Animal health related criteria rather than milk fat percent would determine minimum fiber levels, use of buffers, etc. Acidosis and problems related to that such as founder might or might not become more common, it is difficult to say. However, many research studies and many farm experiences have demonstrated that dietary production of milk with fat content below 3.0% can be accomplished without noticable increases in animal health problems.

Changing Milk Protein and SNF Concentration Through Nutrition

Nutritional factors that affect percentages of milk protein and SNF include 1) energy intake, 2) added fat, and 3) dietary protein percent. Related areas include forage particle size, amount and solubility of dietary starch, and effect of some feed additives. These nutritional effects are exerted through changes in availability of the blood-borne nutrients that are presented to secretory cells in the mammary gland.

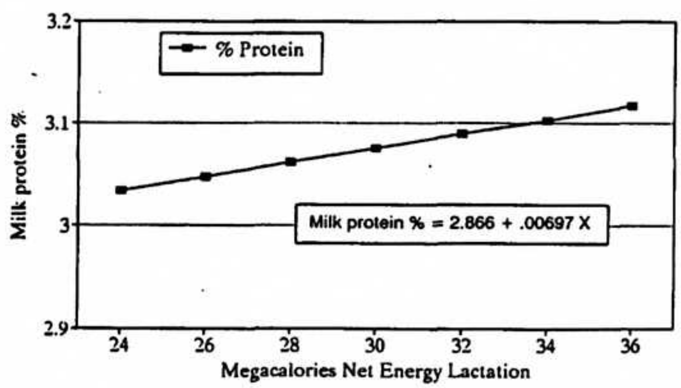
The essential amino acids and most non-essential amino acids needed for milk protein synthesis are derived from blood as is glucose. Glucose is required for production of lactose and for energy to drive the metabolic activity that occurs within the mammary gland. Glucose may also be a source of some carbon skeletons needed to synthesize certain amino acids and the glycerol needed for milk fat synthesis. Propionic acid absorbed from the rumen is a primary precursor of blood glucose produced in the liver.

Energy Intake. Energy intake has been shown to be the primary nutritional factor that affects milk protein and SNF percentages. Factors affecting energy intake which will be discussed include dry matter intake, substitution of concentrates for forages (forage:concentrate ratio), and digestibility of starch. Increasing energy intake with added dietary fat will be considered separately.

Many experiments at other locations have demonstrated that underfeeding results in a drop in protein and SNF contents of milk and that feeding at levels above accepted standards tends to increase these contents. Greater depressions in protein and SNF occur due to substandard feeding than the increases that can be effected through high-energy feeding. Thus, amount eaten regardless of diet composition can have some effect on milk protein content.

As the foundation for our discussion on energy intake, summarized data from 20 separate experiments conducted at the University of Florida from 1970-85 (Briceno et al., 1987) will be used. These experiments were designed to compare factors such as forage:concentrate ratio, diet protein percent, protein source, addition of whole cottonseed, and inclusion of buffers. The variation in diet energy content in these experiments primarily was due to change in concentrate percent from 30 (low-energy diets) to 75 (high-energy diets). Forage components consisted of corn silage, alfalfa, cottonseed hulls, perennial peanut, or sugarcane bagasse. Concentrates generally were based on ground corn. The data set included 1688 individual cow responses to dietary treatments. These previously reported responses (Briceno et al., 1987) and some unreported analyses of this same data set were used to make the economic comparisons included in this paper.

Figure 2. Effect of Megacalories of Net Energy Intake on Milk Protein Percent



The effect of total energy intake on milk protein percent was positive and linear as shown in Figure 2. Energy intake usually is increased by increasing the energy concentration of diet dry matter through the inclusion of a higher proportion of concentrate. However, the resultant energy concentration often is not correlated perfectly with total energy intake because dry matter intake may change slightly as dietary energy concentration is changed.

Figure 3. Effect of Dietary Energy Concentration on Milk Fat and Protein %

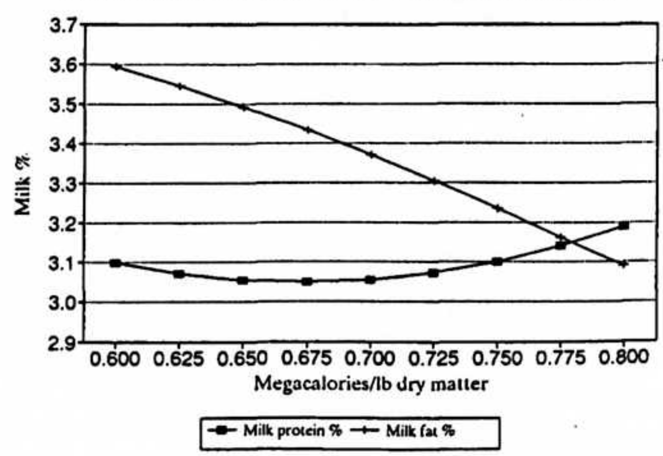


Figure 3 summarizes the typical changes in milk protein and milk fat percentages that are associated with change in diet energy concentration. An almost linear decline in milk fat percent occurred as dietary energy concentration was increased. However, in some experiments, milk fat percents were well maintained at intermediate energy levels. Change in milk protein percent, although positive, was better described with a curved line in this analysis. This is in contrast with the linear response associated with total energy intake (Figure 2).

Diet changes which tend to produce a high proportion of propionic acid relative to acetic acid in the rumen usually reduce milk fat percent. The drop in fat percent usually is compensated for by a small increase in milk protein percent and a slight increase in milk yield. Feeding high proportions of concentrate relative to forage usually results in a lower milk fat percentage along with less acetic acid and more propionic acid production. In some experiments the efficiency of recovery of dietary energy in milk energy is reduced. However, with proper processing of starchy grains, it may be possible to maintain or improve efficiency of energy conversion by effecting an increase in production of milk which is slightly higher in milk protein and lower in milk fat. For example, three recent experiments at the University of Arizona which utilized steam-flaked sorghum grain stimulated increased milk yield and higher milk protein percentages with only moderate milk fat depression (Table 2). Although, molar proportions of rumen volatile fatty acids were not reported, it is probable that some change in rumen acetic:propionic acid proportions occurred. The Arizona researchers feel that the major gain in efficiency is through improved starch utilization. Their data suggest that moderate flaking to a bulk density of 34 pounds per bushel is adequate compared to thinner flaking (e.g. bushel weights of 25 or 21 pounds) which they showed resulted in more rapid starch degradation.

Table 2. Effect of steam flaking of sorghum grain on milk production efficiency and milk composition.[1]

	Experiment 1		Experiment 2			Experiment 3		
Response	DRS	SFS	DRS	SFS	Mix	DRS	SFS1	SFS2
DM intake, kg/day	20.7	20.3	26.1	24.8	29.4	25.8	25.4	23.8
Milk yield, kg/d	28.1	31.5	29.4	31.0	30.9	30.0	33.3	31.7
FCM yield, kg/d	28.2	29.8	30.6	30.8	29.7	30.4	31.6	29.4
Milk fat %	3.57	3.20	3.73	3.64	3.33	3.40	3.23	3.05
Milk protein %	2.90	2.98	2.95	3.10	3.06	3.14	3.20	3.17
Efficiency, FCM/DMI	1.38	1.49	1.17	1.24	1.01	1.18	1.24	1.26
Apparent digestibility								
Starch, %	80	97	69.8	92.3	82.5			
NDF, %	39	37	47.2	35.3	41.0			
Steam flaking, lb/bu		25		25			34	21
Gross $ income/day (Formulas described later):								
Formula 1, $.10 dif.	$8.72	9.52	9.22	9.66	9.42	9.20	10.08	9.47
$ gain over DRS		.80		.44	.20		.88	.27
Formula 2, $.07 dif.	8.71	9.58	9.18	9.64	9.46	9.22	10.14	9.57
$ gain over DRS		.87		.46	.28		.92	.35
Formula 3, Cheese dif	8.59	9.31	9.18	9.71	9.33	9.19	10.07	9.38
$ gain over DRS		.72		.53	.15		.88	.19
Formula 4, Calif.	8.66	9.41	9.22	9.73	9.40	9.24	10.12	9.45
$ gain over DRS		.75		.51	.18		.88	.21

[1]Data from Swingle et al., 1990.
DRS = dry rolled sorghum grain, SFS = steam-flaked sorghum grain, FCM = fat corrected milk.

Feeding Ionophores. Ionophores such as Lasalocid and Rumensin are not approved for use in lactating cows. However, some research has been done to test efficacy with cows because they affect rumen fermentation in a such a way that increased propionic acid and reduced acetic acid production occurs. Based on the previous discussion, this shift would be expected to reduce milk fat percent. In addition, both milk protein and milk yield could be expected to increase. Although research data are limited, no consistent benefit to milk yield and milk protein percent have been noted while milk fat percent depression has been observed.

Added Dietary Fat. In contrast to increasing energy through increased dry matter intake, increased percent concentrate, or improved starch utilization, added dietary fat usually decreases milk protein percent. A large number of the experiments that reported depression of milk protein percent with added fat utilized whole cottonseed as the fat source. Although there are a few exceptions, recent experiments confirm that added fat regardless of source reduces milk protein percent. Amount of depression is usually .1 to .3 units. The decline in protein is greatest in the casein fraction. However, the proportional decline in casein may not be greater than the decline in other protein and nonprotein nitrogen fractions. Current data suggest that the protein depressing effect of dietary fat involves post ruminal metabolism since feeding either rumen unprotected or protected fat depresses milk nitrogen. Importantly, inclusion of rumen protected methionine and lysine in diets that contained added fat attenuated partially the depression in total milk nitrogen and casein caused by the added fats (DePeters and Palmquist, 1989). This and a number of other recent studies suggest that dietary protein interacts with fat. Furthermore, increased absorption of protein and of specific limiting amino acids likely will remove much of the depression in milk protein percentage that is due to added dietary fat.

Dietary Protein. For many years it has been accepted that moderate increases in protein content of the diet have no effect on milk protein percent other than a small increase in the nonprotein nitrogen content. However, Emery concluded from his research review that for each 1% increase in dietary protein between 9 and 17% there was an increase of about .02% in milk protein content. In the Briceno data set represented in Figures 2 and 3, the increase was .015% for each 1% increase in dietary protein between 12 and 16% of total diet dry matter. Recent studies with abomasal protein administration usually resulted in an increase in milk protein content. Provision of limiting amino acids is the probable mode of action since abomasal infusion of a combination of methionine and lysine results in a modest increase in milk protein content. Feeding protected methionine or corn gluten meal, an excellent source of methionine, also increased milk protein percent in some studies but not in others.

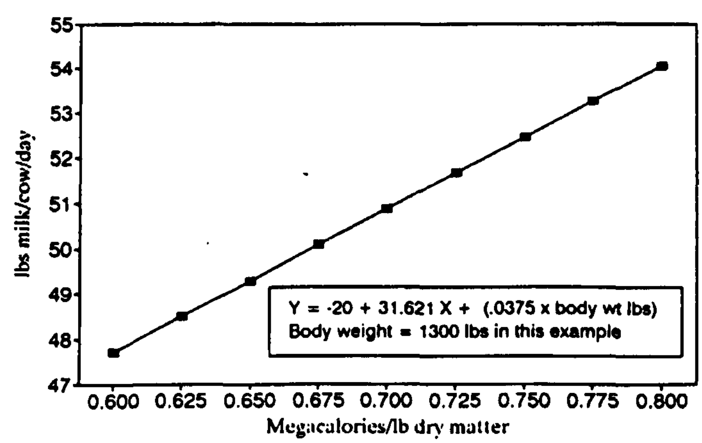
Feeding of protein supplements which are relatively undegradable in the rumen can lower milk protein percent. Dorminey and Harris have just completed a study comparing hydrolyzed feather meal with soybean meal in complete diets for lactating cows which provided either 14 or 18% crude protein. Feather meal at 3 percent of diet dry matter gave a significant response in milk yield over soybean meal in 14% crude protein diets but not at 18%. These results suggest that feeding a high quality, less degradable protein can spare total dietary protein. There was, however, a significant depression in milk protein percent in cows supplemented with feather meal. Minnesota workers at the 1990 ADSA meetings reported a similar effect with a mixture of animal byproducts which included feather meal. North Carolina workers found some depression in milk protein percent when cows were treated intraperitoneally with branched-chain amino acids. Although not reported as statistically significant, studies at Illinois showed that abomasal infusion of arginine resulted in milk protein percent values which were below control values by more than two standard deviations. These results suggest that composition as well as concentration of dietary protein affect mammary gland metabolism and resultant content and yield of milk protein.

Bovine somatotropin (BST) through its effect upon adipose tissue metabolism has an amino acid conservation effect. Less oxidation of amino acids is required to support cell metabolism because other oxidation substrates are made available, namely, glucose, acetate, and fatty acids. Despite this increased availability of amino acids for total protein synthesis, milk protein percentage usually decreases with BST treatment, particularly during early lactation with its associated negative energy and nitrogen balance. This decrease in milk protein percentage probably occurs because in proportion to the precursors for lactose and milk fat synthesis, the amino acids needed for milk protein synthesis are limiting. Consequently, the increased amount of milk fluid produced as a result of increased lactose synthesis will contain a normal or elevated fat content but a relatively depressed protein content.

Economic implications of producing lower fat milk

Consumer preference for low-fat fluid milks and reduced butter consumption continue to add market pressure to produce and price milk in relation to the value of milk and milk products sold. This is reflected in the continued reduction of the milk fat price differential and, particularly in cheese markets, with differentials added for milk protein or solids-not-fat (SNF).

Figure 4. Milk Yield Response to Dietary Energy Concentration



Since it is possible to produce lower-fat milk through dietary manipulations, the question is "when is it going to be profitable for dairymen to deliberately produce lower-fat milk?" To a significant extent, dairymen already are moving in this direction profitably. This is because the trend to higher and higher milk production per cow is associated with reduced milk fat percent. Associated with higher milk production per cow and lower milk fat percents are the continued shift to Holsteins and the necessity of feeding high-energy diets which decreases milk fat percent to achieve high production. Figure 4 shows the response in milk yield obtained by increasing energy concentrations of diets fed to cows within the Briceno data set. This increase in milk yield is associated with the changes in milk fat and milk protein percents depicted in Figure 3.

These responses (milk yield, milk protein percent, milk fat percent) in relation to energy intake will be used to evaluate the economics of producing milk of lower fat content. Furthermore, for comparison, we will use four milk pricing equations to evaluate the effects of varied use and value of milk and milk constituents. They are:

1. A 10 cent fat differential:

   $/cwt = $14.00 for 3.5% milk + [$.10 x (dairy fat % - 3.5)]

   e.g., for 3.2%, milk price = $14.00 + [$.10 x (3.2 - 3.5)] = $13.70

2. A 7 cent fat differential (same as #1 except differential = $.07):

   e.g., for 3.2%, milk price = $14.00 + [$.07 x (3.2 - 3.5)] = $13.79

3. A differential based on variation in estimated cheese yields from milks of varying composition:

   $/cwt = $14.00 for 3.5% milk with variation from this set-point value based on change in potential cheese yield

   To estimate cheddar cheese yields from milks of varying milk protein and milk fat percent, the Van Slyke equation was used for prediction:

$$\text{Cheddar cheese yield} = \frac{[.93\ (\%\ \text{fat}) + (\%\ \text{casein} - 0.1)] \times 1.09}{1 - (\text{cheese moisture}\ \%/100)}$$

   The percent casein value used was 77.4% which was the mean percent for the Southern region obtained by Barbano. Moisture percent used was 37.0. Our standard milk (3.50% milk fat and 3.10% milk protein) was estimated to yield 9.61 lbs cheese/100 lbs milk.

   The value of each milk was then calculated from the value of estimated cheese yield, value of residual fat in the whey, and an added constant which adjusted our standard milk to $14.00/cwt. The price used for cheddar cheese was 80% of $1.11, a recently quoted support price for cheddar cheese in 40-lb blocks. The marketable fat recovered in the whey was 6% of original fat yield and this was valued at $1.00/lb milk fat. The constant needed to adjust standard milk to $14.00 was $5.26. Thus:

   $/cwt = ($1.11 x .80 x cheddar cheese yield) + ($1.00 x .06 x original fat lbs) + $5.26

4. A California pricing formula based on fat %, SNF %, and fluid value:

$/cwt = [($1.1687 x fat yield) + ($.8305 x SNF yield) + ($.0126 x fluid)] x 1.142

Fluid = [100 - (fat yield + SNF yield)]

The multiplier of 1.142 was necessary to adjust price of 3.5% milk which was 8.5% SNF to $14.00/cwt. The need for this multiplier is an indication that prices for the standard milks used in these examples are 14.2% higher than California prices.

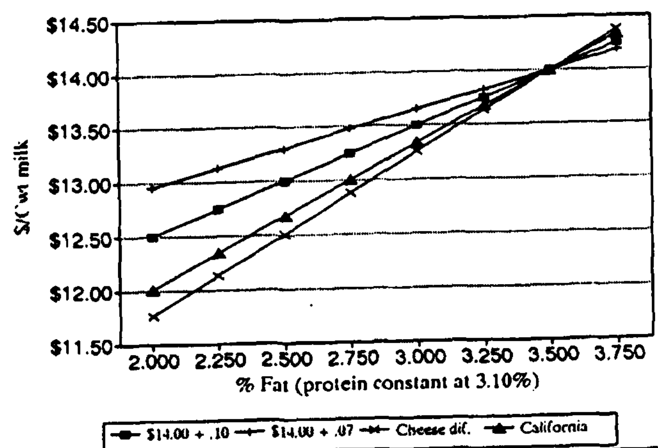


Figure 5. Effect of Pricing Formula on Price of Milks Varied from 3.5%

The above pricing formulas are compared in Figure 5 when starting milks had varied fat contents (2.0 to 3.75%) but a constant (3.1) protein %. As expected, value of starting milk increased as percentage fat increased with all formulas. The formula least responsive to change in fat percentage contained the 7-cent fat differential. The cheese differential equation and the California pricing equation gave almost the same results and were most responsive to changes in fat percent. This is also evident in Figure 6 when these pricing formulas were applied to the seasonal changes in Southern U.S. milk composition which were shown in Figure 1.

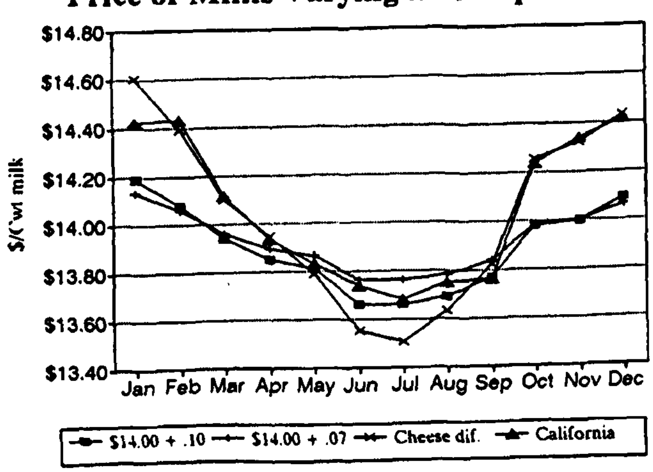
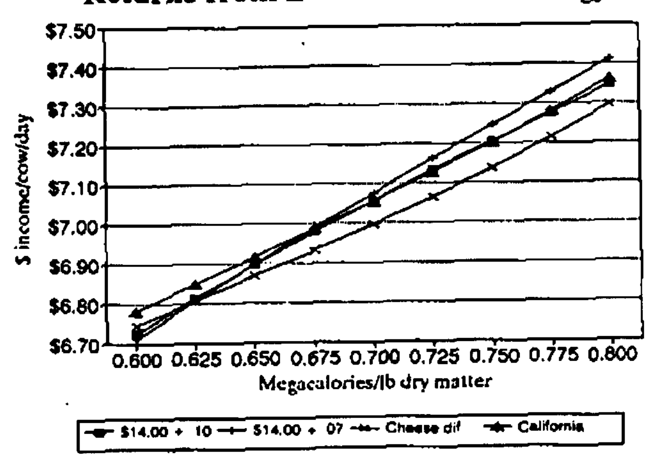


Figure 6. Effect of Pricing Formula on Price of Milks Varying in Composition

The incentive to produce lower-fat milk through nutrition must come from being able to divert the energy saved from reducing fat content in the milk to more pounds of milk which hopefully will contain equal or higher amounts of milk protein and SNF. If we apply these milk pricing equations to the combined effects of energy content/lb of diet dry matter on milk yield (from Figure 4) and milk fat and milk protein % (Figure 3), we obtain an increase in gross income per cow regardless of the milk pricing formula used (see Figure 7).

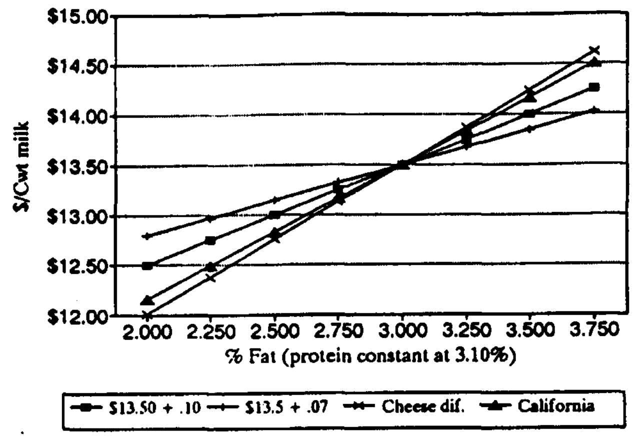
When these pricing formulas were applied to the data in Table 2, the gross dollar returns shown in the bottom section of Table 2 were obtained. By comparing the gross returns that are effected by steam flaking sorghum relative to those associated with dry rolling in the various treatments, the gain in gross returns that can be attributed to the milk yield and composition response effected by feeding steam flaked sorghum can be calculated by difference. There are no major differences due to pricing formula in the gain in daily gross incomes brought about by steam flaking sorghum grain in these experiments. However, the reward is greater for the changes achieved when the $14.00 + $.07 differential was used. The average gain was $.576 for this formula versus $.518, $.494, and $.506 for the others. This result is logical. When you do something that might depress milk fat percent, it is an advantage to be paid with a low fat differential.

Figure 7. Effect of Pricing Formula on Returns from Diets of Varied Energy



When comparing pricing formulas, it should be noted that the two formulas based on fat plus protein or SNF content (the cheese based differential and the California equations) gave very similar prices in all the comparisons (Figures 5-8). Although intuitively it is important that the producer price of milk be determined in relation to the final product-producing potential of the milk, including its fluid value, there is little incentive for primarily fluid markets like Florida to include a protein or SNF differential until the market milk standards are raised to where additional fortification of fluid milks above the market pool composition is necessary. However, a point of possible importance when comparing the four pricing formulas is the effect of the base-point fat percent on the difference between prices as fat percents decline. For example, Figure 8 shows the formulas compared when 3.0% fat was the point of equalization. The $.10 differential equation gives exactly the same prices as before but now is based on $13.50 for 3.0% instead of $14.00 for 3.5%. The other equations were calculated as before but the constants were adjusted to make prices equal for 3.0% fat milks. The effect is to make the range much wider for 2.0% fat milks when prices are calculated further from the base point ($1.18 range in prices for 2.0% milks when prices are equalized at 3.5% base, Figure 5, and $.79 range when base prices are equalized at 3.0%, Figure 8).

Figure 8. Effect of Pricing Formulas on Price of Milks Varied from 3.0%



Summary

Milk protein and SNF percentages vary together and can be changed through dietary manipulation. However, the amount of change possible is small compared to the change that could be effected in milk fat percentage. Dietary energy level as influenced by extent of carbohydrate utilization is the major factor affecting milk protein percentage. Unfortunately, supplemental energy provided through dietary fat usually depresses milk protein by .1 to .3 percentage units. Increasing dietary crude protein usually has little or no effect on milk protein percentage. However, dietary protocols which increase intestinal absorption of limiting amino acids might increase milk protein by .1 to .2 percentage units particularly when they are included with diets where added fat has depressed milk protein percentage.

With current milk pricing and with pricing formulas proposed for the future, the incentive remains to produce milk with lower fat content if slightly more milk yield accompanies that change. If the trend continues toward lower fat content in market pools of milk, more equitable pricing can probably be accomplished if the base point is lowered from 3.5% in order minimize differences between various pricing formulas for lower-fat raw milks.