AN ECONOMIC AND STATISTICAL ANALYSIS OF SOLIDS-NOT-FAT AND PROTEIN COMPONENTS OF MILK

Larry Luedtke
and
Randall Stelly

August 1975

The Texas Agricultural Market Research and Development Center
in cooperation with
Department of Agricultural Economics
Texas A&M University
The Texas Agricultural Experiment Station
College Station, Texas

THE TEXAS AGRICULTURAL MARKET RESEARCH AND DEVELOPMENT CENTER

An Education and Research Service
of
The Texas Agricultural Experiment Station
and
The Texas Agricultural Extension Service

The purpose of the Center is to be of service to agricultural producers, groups and organizations, as well as processing and marketing firms in the solution of present and emerging market problems. Emphasis is given to research and educational activities designed to improve and expand the markets for food and fiber products related to Texas agriculture.

The Center is staffed by a basic group of professional agricultural and marketing economists from both the Experiment Station and Extension Service. In addition, support is provided by food technologist, statisticians and specialized consultants as determined by the requirements of individual projects.

Robert E. Branson
Coordinator

This research report was made possible in part by a grant from the Office of the Administrator of the North Texas Milk Market Order.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY AND CONCLUSIONS

Summary

Pricing milk to producers according to its components has been discussed for several years by many people in the dairy industry. The per capita civilian consumption of fluid whole milk decreased from 278 pounds in 1950, to 266 pounds in 1965, and 201 pounds in 1974. During this same period, the per capita civilian consumption of low-fat and skim milk increased from 15.6 pounds in 1950, to 34.2 pounds in 1965, and 78.1 pounds in 1974. The increase in consumer demand for low-fat and skim products indicates the need for a change in the present pricing procedure. What is needed is a pricing procedure that compensates producers for the SNF and protein components in their milk in a manner that will encourage production of the nonfat components.

The concern by the Food and Drug Administration to further protect consumers leads some people in the dairy industry to believe that nutritional labeling of food will soon be a reality. If and when nutritional labeling is required, the dairy industry will be forced to account for the components of milk other than butterfat. When milk handlers have to account for the nonfat or protein solids as well as the butterfat in fluid consumer products, the value of the nonfat solids will take on added significance. When this occurs, the nonfat portion of milk will have to become a factor in the pricing procedure.

The data used in this study was obtained from the records of the Federal Milk Market Administrator's Office for the North Texas market

in Dallas, Texas. The data consisted of the actual monthly SNF contents of producer milk for a 120-month period, January, 1965, through December, 1974. The actual montly protein content of milk was available for 36 months, January, 1972, through December, 1974. Usually, the SNF content of milk is determined by applying Jacobsen's formula to determine a predicted amount of SNF rather than the actual amount. However, the data used in this study represents the actual SNF content, since the milk for each of the 120 months had been tested by personnel in the Market Administrator's Office. The same is applicable for the protein data.

The data was subjected to regression analysis to determine the relationships that exist between the components. The data for each of the components was analyzed for seasonality through the use of dummy variables. Duncan's multiple range test was then used to determine significance between seasons.

The data shows a strong direct relationship between the three milk components: butterfat, SNF, and protein. Seasonality exists throughout the data, and as one component moves up or down, the others do likewise due to the direct relationships. The correlations between the three components are also very high.

On the basis of these relationships, and with the actual prices available for the 120-month period, a hypothetical SNF and protein differential was introduced. The dollar value of the new differentials was based on the actual price of manufactured products. The actual producer-pay-price is shown along with a new price based on the introduction of the additional component differential.

Results of the analysis are summarized as follows:

1. The linear expression of SNF on BF was SNF = 7.3325 + .3541 BF.

2. The seasonality of SNF over time indicates significant variation by months.

3. The seasonality of BF over time, likewise indicates significant variation by months.

4. There was no significant difference for either SNF or BF over time by years.

5. Combining the analysis of both month and year indicates that SNF has not changed over the 10-year period, while BF decreased by 4.6 percent from 1965-1974.

6. Both SNF and BF show significant, parallel variation by seasons.

7. The linear expression of Pro on BF was 1.1707 + .5729 BF.

8. The linear expression of Pro on SNF was -6.2810 + 1.1031 SNF.

9. The seasonality of Pro over time indicates significant variation by months and seasons.

Conclusions

1. Paying on a component basis would be to the advantage of some producers and to the disadvantage of others, but at the same time, it would eliminate some of the present inequities in the milk pricing and payment procedure.

2. Component pricing would result in additional expense for handlers, producer cooperatives, and milk market administrators due to the additional testing of samples and accounting.

3. It would require handlers to "double-standardize" milk according to both fat and nonfat or protein, and develop an accounting system to keep track of the additional components.

4. Component pricing and its ramifications would help to satisfy the requirements for nutritional labeling when it is required.

5. Component pricing would aid in communicating the consumers' preferences back to producers through the pricing mechanism.

6. Producer milk would be priced more according to the true market value of the various components--both with respect to fat as well as the SNF and protein it contains--if a component pricing procedure was adopted.

AN ECONOMIC AND STATISTICAL ANALYSIS OF SOLIDS-NOT-FAT AND PROTEIN COMPONENTS OF MILK

Larry Luedtke and Randall Stelly*

INTRODUCTION

Component pricing of milk is a subject that is being discussed more frequently by the entire dairy industry because of shifts in consumer demand for dairy products. Over the past few years, the fat content of milk has decreased in importance and in value to the consumer. The advent of margarine, with the use of vegetable oils such as peanut oil and soybean oil, resulted in a decreased demand for butter and a decrease in milkfat value. Recently, nondairy coffee creamers and synthetic whipping creams have further lessened the demand for milkfat. The nutritional value of milk with a high fat content has been under attack by various medical professionals regarding the high cholestrol content of animal fat. A body-weight conscious society also demands less fat in their milk and milk products.

During this period of decreased demand for milkfat came an increase in demand for low-fat products, such as low-fat milk, fortified skim milk, cottage cheese, and recently, yogurt. Yet, these low-fat products are standardized according to butterfat content and not protein or SNF content. This increase in demand for low-fat products is very evident in the trends in milk values. The skim value has been continually rising while the fat value has declined relative to the skim value.

---

*Research Assistant and Associate Professor, respectively, Department of Agricultural Economics, Texas Agricultural Experiment Station, Texas A&M University.

During the past decade and a half, prices of manufactured products have changed relative to each other due to changes in demand for the nonfat components. In 1949, the government support price for nonfat dry milk averaged 12.5 cents per pound and for butterfat it averaged 62 cents per pound. In 1949 it took 5.06 pounds of powder to equal one pound of butter. In 1970 this ratio was less than three to one (Luke, 1971). Between 1965 and 1970 butter prices at wholesale increased 11 percent, while cheese prices rose 36 percent and nonfat dry milk prices rose 88 percent. From 1965 to 1970 the price of nonfat milk solids increased eight times more than the price of the fat portion (Johnson). Producer prices have also changed as indicated by the following table developed by Jacobsen (Jacobsen, Robert, 1974).

U.S. Average Prices	1965	1973
Blend Price	$4.63	$7.46
Butterfat Differential	7.2¢	8.2¢
3.5 Butterfat (percent of total)	56%	39.7%
96.5 Skim (percent of total)	44%	60.3%

The mechanism for relaying the consumer's demand to the producer is the pricing system. Yet, the pricing system now being used is incapable of performing such a task. The incentive for the producer is to produce large volumes of milk with a high fat content. The producer can in no way be economically rewarded for producing the other components of milk, SNF and protein, desired by the consumer under the present pricing procedure.

The basic formula used in all federal orders is the Minnesota-Wisconsin (M-W) formula. This "basic formula price" is the average price paid for manufacturing grade milk by selected handlers in Minnesota and Wisconsin as reported by the Department of Agriculture. This price is then adjusted to 3.5 percent butterfat basis. This M-W price is computed monthly. Whenever the M-W price falls below a certain parity level, the government, through the Commodity Credit Corporation, commences purchasing manufactured products, butter, cheese, and powder in an attempt to raise prices. By buying these products the government removes the excess supply from the market. The manufacturing plants then are able to pay more for manufacturing grade milk which in turn causes the M-W price to rise.

All other prices in the federal order pricing procedure are calculated directly from the M-W price. The Class III price in 55 of the 60 federal order markets is, in fact, the M-W price. The remaining five markets use the lower of the M-W price or the butter-powder formula price. The Class II price in all federal order markets is the M-W price, plus 10 cents. The M-W price is the mover of Class I prices in all federal order markets.

The Class I price is determined on the basis of the M-W price for the second preceeding month. For example, in calculating the July Class I price, the May formula price is used. To this M-W price is added a sum called the fluid differential, which partially reflects the extra or added economic value of Grade "A" Milk over the basic value of manufacturing grade milk and the cost of transporting milk from the Chicago area, to the North Texas Market area.

In a market-wide pool the total money value of all milk delivered by all producers to all handlers (pounds of milk in each class multiplied by the respective class price) within an order is combined into one pool.

The total value is then divided by the total amount of producer milk to determine a minimum uniform, or blend price. All producers are paid not less than this blend price per hundredweight for their milk deliveries. This uniform price is calculated for milk containing 3.5 percent butterfat. A butterfat differential is established when the uniform price is calculated to adjust for variations in the butterfat content of producer milk. Therefore, the only way for price to differ between two neighboring producers operating under the same federal order is for them to produce milk with different butterfat content.

The purpose of this study is to analyze 10 years of data concerning the North Texas Milk Market both statistically and economically. A statistical analysis of the variation of butterfat, SNF, and protein solids in milk delivered by producers in the North Texas Milk Market was conducted to determine the relationships and trends among the three components. An evaluation of the nonfat components in milk in terms of price and value was made in comparison to butterfat prices and values. Finally, two different hypothetical differentials were developed and incorporated into the present pricing procedure to determine their effects on producer income compared to the present method of pricing milk.

METHODOLOGY

Sources of Data

The data used in this study was obtained from the office of the Federal Milk Market Administrator in Dallas, Texas. The data consist of the following items:

1. Class I Price Summary of the North Texas Federal Order Market - 1965 - 1974 (Table 1)
2. Class II Price Summary of the North Texas Federal Order Market - 1965 - 1974 (Table 2)
3. Monthly Average Butterfat Content in Pounds of Producer Milk in the North Texas Federal Order Market - January, 1965 - December, 1974 (Table 3)
4. Monthly Average Content in Pounds of SNF in Producer Whole Milk in the North Texas Federal Order Market - January, 1965 - December, 1974 (Table 4)
5. Monthly Average Content in Pounds of Protein in Producer Whole Milk in the North Texas Federal Order Market - January, 1972 - December, 1974 (Table 5)
6. Relationship of Protein on SNF in the Skim Milk Portion of Producer Milk Received by Plants Located in the North Texas Marketing Area - January, 1972 - December, 1974 (Table 6)

All of the above data were developed from monthly production, deliveries, and utilization of producer milk in the North Texas market as determined by the records and auditing activities of the market administrator's office.

The price data were the actual class prices in effect each month from January, 1965, through December, 1974, and were used in calculating the monthly blend prices.

The geographic area for the North Texas Milk Market consists of 44 counties in North and Northeast Texas surrounding the Dallas-Fort Worth area.

Table 1. Class I Price Summary of the North Texas Federal Order Market - 1965 - 1974

			Butterfat		Skim Milk	
Year	Avg. Cl. I Price/cwt. 3.5% B.F.	Avg. B.F. Diff.	Value of 3.5 lbs. of B.F.	Percent [1]	Value of 96.5 lbs. of Skim	Percent [1]
1965	$ 5.20	7.5	$ 2.625	50.5	$ 2.575	49.5
1966	6.08	8.3	2.905	47.8	3.175	52.2
1967	6.33	8.3	2.905	45.9	3.425	54.1
1968	6.56	8.3	2.905	44.3	3.655	55.7
1969	6.73	8.5	2.975	44.2	3.755	55.8
1970	6.97	8.6	3.010	43.2	3.960	56.8
1971	7.12	8.6	3.010	42.3	4.110	57.7
1972	7.32	8.6	3.010	41.1	4.310	58.9
1973	8.25	8.7	3.045	36.9	5.205	63.1
1974	9.58	8.0	2.800	29.2	6.780	70.8

---

[1] Represents the percentage of the value of 3.5% milk assigned to Butterfat and Skim Milk, respectively.

Table 2. Class II Price Summary of the North Texas Federal Order Market - 1965 - 1974

			Butterfat		Skim Milk	
Year	Avg. Cl. I Price/cwt. 3.5% B.F.	Avg. B.F. Diff.	Value of 3.5 lbs. of B.F.	Percent 1/	Value of 96.5 lbs. of Skim	Percent 1/
1965	$ 3.086	6.9	$ 2.415	78.3	$ .671	21.7
1966	3.664	7.6	2.660	72.6	1.004	27.4
1967	3.784	7.5	2.625	69.4	1.159	30.6
1968	3.991	7.6	2.660	66.6	1.331	33.6
1969	4.120	7.6	2.660	64.6	1.460	35.4
1970	4.441	7.9	2.765	62.3	1.676	37.7
1971	4.736	7.8	2.730	57.6	2.006	42.4
1972	5.174	7.8	2.730	52.8	2.444	47.2
1973	6.121	8.0	2.800	45.7	3.321	54.3
1974	6.902	7.5	2.625	38.0	4.277	62.0

1/ Represents the percentage of the value of 3.5% milk assigned to Butterfat and Skim Milk respectively.

Table 3. Monthly Average Butterfat Content in Pounds of Producer Milk in the North Texas Federal Order Market - January, 1965 - December, 1974

Pounds of Butterfat in 100 Pounds of Whole Milk

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
1965	3.82	3.83	3.75	3.57	3.58	3.56	3.53	3.55	3.64	3.81	3.82	3.83	3.69
1966	3.86	3.86	3.69	3.56	3.57	3.52	3.50	3.58	3.72	3.84	3.83	3.86	3.69
1967	3.83	3.74	3.63	3.51	3.49	3.48	3.49	3.49	3.64	3.72	3.81	3.82	3.63
1968	3.85	3.71	3.66	3.43	3.43	3.44	3.45	3.47	3.56	3.68	3.79	3.83	3.60
1969	3.74	3.69	3.66	3.48	3.44	3.44	3.41	3.43	3.53	3.67	3.80	3.77	3.58
1970	3.80	3.67	3.61	3.39	3.39	3.43	3.38	3.40	3.51	3.66	3.77	3.70	3.56
1971	3.72	3.66	3.59	3.48	3.43	3.39	3.38	3.50	3.54	3.65	3.70	3.79	3.56
1972	3.73	3.66	3.52	3.44	3.42	3.40	3.39	3.42	3.49	3.62	3.83	3.84	3.56
1973	3.79	3.65	3.48	3.37	3.35	3.37	3.38	3.38	3.49	3.59	3.66	3.71	3.52
1974	3.75	3.63	3.52	3.44	3.37	3.34	3.33	3.38	3.52	3.61	3.68	3.70	3.52
Avg.	3.79	3.71	3.61	3.47	3.45	3.44	3.42	3.46	3.56	3.69	3.77	3.79	

Table 4. Monthly Average Content in Pounds of SNF in Producer Whole Milk in the North Texas Federal Order Market - January, 1972 - December, 1974

	Pounds of SNF in 100 Pounds cf Whole Milk												
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
1965	8.603	8.609	8.599	8.657	8.624	8.511	8.457	8.476	8.482	8.580	8.626	8.642	8.573
1966	8.663	8.605	8.586	8.643	8.600	8.531	8.485	8.494	8.631	8.682	8.667	8.635	8.600
1967	8.623	8.630	8.604	8.570	8.634	8.587	8.543	8.510	8.548	8.611	8.707	8.673	8.601
1968	8.691	8.664	8.631	8.617	8.572	8.536	8.493	8.508	8.568	8.636	8.729	8.692	8.611
1969	8.658	8.671	8.644	8.670	8.635	8.572	8.523	8.489	8.576	8.727	8.782	8.741	8.640
1970	8.702	8.689	8.650	8.704	8.613	8.538	8.486	8.447	8.559	8.698	8.798	8.690	8.628
1971	8.703	8.702	8.672	8.649	8.597	8.518	8.469	8.540	8.556	8.620	8.711	8.740	8.624
1972	8.693	8.654	8.610	8.601	8.569	8.507	8.494	8.495	8.517	8.633	8.764	8.781	8.606
1973	8.717	8.659	8.641	8.691	8.630	8.528	8.447	8.444	8.497	8.562	8.645	8.648	8.592
1974	8.667	8.596	8.572	8.571	8.533	8.497	8.462	8.480	8.583	8.625	8.632	8.644	8.566
Avg.	8.672	8.648	8.621	8.637	8.601	8.533	8.486	8.488	8.552	8.637	8.706	8.689	

Table 5. Monthly Average Content in Pounds of Protein in Producer Whole Milk in the North Texas Federal Order Market - January, 1972 - December, 1974

	Pounds of Protein in 100 Pounds of Whole Milk												
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
1972	3.281	3.226	3.172	3.175	3.172	3.106	3.162	3.163	3.223	3.340	3.450	3.439	3.237
1973	3.361	3.296	3.245	3.260	3.207	3.101	3.055	3.072	3.139	3.272	3.294	3.238	3.209
1974	3.199	3.117	3.075	3.102	3.066	3.031	2.983	3.038	3.195	3.273	3.255	3.268	3.127
Avg.	3.280	3.213	3.164	3.179	3.148	3.079	3.067	3.091	3.186	3.295	3.333	3.315	

Table 6. Relationship of Protein on SNF in the Skim Milk Portion of Producer Milk Received by Plants Located in the North Texas Marketing Area - January, 1972 - December, 1974

		% SNF in Producer Skim Portion	% Protein in Producer Skim Portion	% Protein is of the SNF
1972	January	9.030	3.408	37.74
	February	8.983	3.349	37.28
	March	8.924	3.288	36.84
	April	8.907	3.288	36.91
	May	8.872	3.284	37.02
	June	8.806	3.215	36.51
	July	8.792	3.273	37.23
	August	8.796	3.275	37.23
	September	8.825	3.340	37.85
	October	8.957	3.465	38.68
	November	9.113	3.587	39.36
	December	9.132	3.576	39.16
	Wt./Avg. for Year	8.924	3.357	37.62
1973	January	9.060	3.493	38.55
	February	8.987	3.421	38.07
	March	8.953	3.362	37.55
	April	8.994	3.374	37.51
	May	8.929	3.318	37.16
	June	8.825	3.209	36.36
	July	8.743	3.162	36.17
	August	8.739	3.179	36.38
	September	8.804	3.252	36.94
	October	8.881	3.394	38.22
	November	8.973	3.419	38.10
	December	8.981	3.363	37.45
	Wt./Avg. for Year	8.905	3.326	37.35
1974	January	9.005	3.324	36.91
	February	8.920	3.234	36.26
	March	8.885	3.187	35.87
	April	8.876	3.212	36.19
	May	8.831	3.173	35.93
	June	8.791	3.136	35.67
	July	8.753	3.086	35.26
	August	8.777	3.144	35.82
	September	8.896	3.312	37.23
	October	8.948	3.396	37.95
	November	8.962	3.379	37.70
	December	8.976	3.394	37.81
	Wt./Avg. for Year	8.879	3.241	36.50

Models Used

A total of 13 models were used. These are as follows:

(1) $$Y\ (SNF) = a + B_1\ (Butterfat) + e$$

(Test for the simple linear relationship of SNF on butterfat.)

(2) $$Y\ (SNF) = a + M_i + e$$

(Test for the variation in SNF due to time by months.)

(3) $$Y\ (BF) = a + M_i + e$$

(Test for the variation on BF due to time by months.)

(4) $$Y\ (SNF) = a + Y_i + e$$

(Test for the variation in SNF due to time by years.)

(5) $$Y\ (BF) = a + Y_i + e$$

(Test for the variation in BF due to time by years.)

(6) $$Y\ (SNF) = a + M_i + B\ (Year) + e$$

(Test for the variation in SNF due to time with months and years combined.)

(7) $$Y\ (BF) = a + M_i + B\ (Year) + e$$

(Test for the variation in BF due to time with months and years combined.)

(8) $$Y\ (SNF) = a + S_i + e$$

(Test for the variation in SNF due to time by seasons.)

(9) $$Y\ (BF) = a + S_i + e$$

(Test for the variation in BF due to time by seasons.)

(10) $$Y\ (PRO) = a + B_1\ (Butterfat) + e$$

(Test for the simple linear relationship of protein on BF.)

(11) $$Y\ (PRO) = a + B_1\ (SNF) + e$$

(Test for the simple linear relationship of protein on SNF.)

(12) $$Y\ (PRO) = a + M_i + e$$

(Test for the variation in protein due to time by months.)

(13) $$Y\ (PRO) = a + S_i + e$$

(Test for the variation in protein due to time by seasons.)

M_i = effect of month i

Y_i = effect of year i

S_i = effect of season i

RESULTS OF DATA ANALYSIS

The first model that was applied to the data was the linear expression:

(1) $Y\ (SNF) = a + B_1\ (Butterfat) + e$

This was used to see if the basic relationship that Dr. Jack had determined in his California experiment in 1951 had changed to any great degree. He determined that SNF = 7.07 + .444 BF.

The data in this study was subjected to the linear expression above with the following results:

$$SNF = \underset{(57.2055)}{7.3325} + \underset{(9.9427)}{.3541}\ BF$$

The coefficient (.3541) was significant at the .0001 level. The standard deviation was .0609, indicating that very little variation existed among the sample observations. The correlation coefficient (r) was .6752, meaning that there is a strong relationship between SNF and butterfat. The overall means were SNF = 8.6058 and BF = 3.5957 for the 120 observations. However, the R^2 was .4559 meaning that less than one-half of the variation in SNF was answered by the above model.

The next six models help to uncover the trends in the two variables over time. The two variables, SNF and butterfat, were placed in models as the dependent variable with time in months, years, or both as the independent variable.

(2) $Y\ (SNF) = a + B_1\ (Month) + e$

(3) $Y\ (BF) = a + B_1\ (Month) + e$

The results for SNF are shown in Table 7. In this case, the model has an F value of 32.7881 which is significant at the .0001 level. The R^2 of .7696 indicates that a large part of the variation in SNF was answered by the model. The intercept (8.6058) is the overall SNF mean. The T and probability values for the dummy variables indicate which months are significantly different for the overall 10-year average. At the 1 percent level of significance January, February, November, and December are significantly higher, while June, July, August, and September are significantly lower.

The results for butterfat are shown in Table 8. In this model, the F value is 42.4879 which is significant at the .0001 level. The R^2 of .8123 indicates that 81 percent of the variation in butterfat is answered by the above model. The intercept (3.5957) is the overall mean for butterfat. The T and probability values show butterfat content in January, February, October, November, and December to be significantly above average; April, May, June, July, and August are significantly below average, while March and September are not significantly different from average.

Using time in months as a dummy variable, the two above models show that SNF and BF do vary throughout the year, and that seasonality does exist.

The next two models use time in years as the dummy independent variable.

(4) $Y\ (SNF) = a + B_1\ (Year) + e$

(5) $Y\ (BF) = a + B_1\ (Year) + e$

Table 7. Results of the Regression Equation: $SNF = a + B_1$ (Month)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	11	0.6183	0.0562	32.7881	.0001
Error	108	0.1851	0.0017		R-Square
Total	119	0.8034			.7696

Source	B Values	T for HO:B=0	Probability T
Intercept	8.6058	2276.8608	.0001
Dummy 1	0.0662	5.2835	.0001
Dummy 2	0.0423	3.3708	.0010
Dummy 3	0.0152	1.2111	.2285
Dummy 4	0.0315	2.5163	.0133
Dummy 5	- 0.0052	- 0.4154	.6787
Dummy 6	- 0.0734	- 5.8518	.0001
Dummy 7	- 0.1199	- 9.5659	.0001
Dummy 8	- 0.1174	- 9.3643	.0001
Dummy 9	- 0.0542	- 4.3242	.0001
Dummy 10	0.0318	2.5342	.0127
Dummy 11	0.1003	8.0050	.0001
Dummy 12	0.0827	6.6007	.0001

Table 8. Results of the Regression Equation: $BF = a + B_1$ (Month)

Source	DF	Sum of Square	Mean Square	F Value	Probability F
Regression	11	2.3727	0.2157	42.4879	.0001
Error	108	0.5483	0.0051		R-Square
Total	119	2.9209			.8123

Source	B Values	T for H0:B=0	Probability T
Intercept	3.5957	552.8162	.0001
Dummy 1	0.1933	8.9621	.0001
Dummy 2	0.1143	5.3000	.0001
Dummy 3	0.0153	0.7108	.4787
Dummy 4	- 0.1287	- 5.9645	.0001
Dummy 5	- 0.1487	- 6.8916	.0001
Dummy 6	- 0.1587	- 7.3551	.0001
Dummy 7	- 0.1717	- 7.9578	.0001
Dummy 8	- 0.1357	- 6.2890	.0001
Dummy 9	- 0.0317	- 1.4680	.1450
Dummy 10	0.0893	4.1411	.0001
Dummy 11	0.1733	8.0350	.0001
Dummy 12	0.1893	8.7767	.0001

The results for SNF by year are shown in Table 9. This model is not significant at either the 5 percent or 1 percent levels, and the R^2 (.0701) is very low, indicating that this model is very poor in answering the variation of SNF. None of the B values are significant, indicating that yearly averages are not significantly different from the overall average.

The results for BF by year are shown in Table 10. The model for BF is not significant at the 1 percent level and the R^2 (.1485) is very low, indicating that this model is also very poor in answering BF variation. None of the B values are significant, indicating that the individual yearly averages for butterfat did not significantly differ from the overall average.

The next two models use months and years as the independent variable.

(6) $Y\ (SNF) = a + B_1\ (Month) + B_2\ (Year) + e$

(7) $Y\ (BF) = a + B_1\ (Month) + B_2\ (Year) + e$

The results for SNF are shown in Table 11. The important statistic in this model is the B coefficient for year. The coefficient (- .0007) indicates that SNF has been decreasing very slightly but not significantly.

The results for BF are shown in Table 12. The coefficient for year (- .0200) is significant at the .0001 level indicating that the annual average butterfat content of milk decreased significantly over the 10-year period.

The last two models (#6 and #7) show that over the 10-year period SNF has not decreased while butterfat has declined. This change helps

Table 9. Results of the Regression Equation: SNF = a + B_1 (Year)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	9	0.0563	0.0063	0.9209	0.5106
Error	110	0.7471	0.0068		R-Square
Total	119	0.8034			.0701

Source	B Values	T for H0:B=0	Probability T
Intercept	8.6058	1143.8618	.0001
Dummy 1	- 0.0337	- 1.4912	.1388
Dummy 2	- 0.0039	- 0.1740	.8622
Dummy 3	- 0.0024	- 0.1071	.9149
Dummy 4	0.0056	0.2478	.8047
Dummy 5	0.0349	1.5483	.1244
Dummy 6	0.0253	1.1220	.2643
Dummy 7	0.0174	0.7701	.4429
Dummy 8	0.0040	0.1781	.8590
Dummy 9	- 0.0134	- 0.5951	.5530
Dummy 10	- 0.0338	- 1.4991	.1367

Table 10. Results of the Regression Equation: $BF = a + B_1$ (Year)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	9	0.4338	0.0482	2.1316	.0322
Error	110	2.4872	0.0226		R-Square
Total	119	3.9309			.1485

Source	B Values	T for H0:B=0	Probability T
Intercept	3.5957	261.9464	.0001
Dummy 1	0.0952	2.3110	.0227
Dummy 2	0.1035	2.5134	.0134
Dummy 3	0.0418	1.0159	.3119
Dummy 4	0.0127	0.3076	.7590
Dummy 5	- 0.0073	- 0.1781	.8590
Dummy 6	- 0.0365	- 0.8864	.3774
Dummy 7	- 0.0265	- 0.6435	.5212
Dummy 8	- 0.0323	- 0.7852	.4340
Dummy 9	- 0.0773	- 1.8779	.0630
Dummy 10	- 0.0732	- 1.7767	.0784

Table 11. Results of the Equation: SNF = a + B_1 (Month) + B_2 (Year)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	12	0.6183	0.0515	29.7783	.0001
Error	107	0.1851	0.0017		R-Square
Total	119	0.8034			.7696

Source	B Values	T for H0:B=0	Probability T
Intercept	8.6101	93.6288	.0001
Dummy 1	0.0662	5.2590	.0001
Dummy 2	0.0423	3.3552	.0011
Dummy 3	0.0152	1.2055	.2307
Dummy 4	0.0315	2.5046	.0138
Dummy 5	- 0.0052	- 0.4135	.6801
Dummy 6	- 0.0734	- 5.8247	.0001
Dummy 7	- 0.1199	- 9.5216	.0001
Dummy 8	- 0.1174	- 9.3209	.0001
Dummy 9	- 0.0542	- 4.3042	.0001
Dummy 10	0.0318	2.5225	.0131
Dummy 11	0.1003	7.9679	.0001
Dummy 12	0.0827	6.5702	.0001
Year	- 0.0007	- 0.0467	.9628

Table 12. Results of the Equation: $BF = a + B_1 \text{ (Month)} + B_2 \text{ (Year)}$

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	12	2.7683	0.2307	161.6697	.0001
Error	107	0.1527	0.0014		R-Square
Total	119	2.9209			.9477

Source	B Values	T for H0:B=0	Probability T
Intercept	4.9850	59.6932	.0001
Dummy 1	0.1933	16.9045	.0001
Dummy 2	0.1143	9.9970	.0001
Dummy 3	0.0153	1.3407	.1829
Dummy 4	- 0.1287	- 11.2502	.0001
Dummy 5	- 0.1487	- 12.9990	.0001
Dummy 6	- 0.1587	- 13.8733	.0001
Dummy 7	- 0.1717	- 15.0100	.0001
Dummy 8	- 0.1357	- 11.8623	.0001
Dummy 9	- 0.0317	- 2.7689	.0066
Dummy 10	0.0893	7.8110	.0001
Dummy 11	0.1733	15.1558	.0001
Dummy 12	0.1893	16.5547	.0001
Year	- 0.0200	- 16.6506	.0001

to explain the change in the relationship of SNF and BF from what Jack, et al., found in 1951, to the present relationship in Model #1.

The next step was to analyze the data to see if SNF and butterfat vary throughout the seasons of the year. The use of the dummy variable was incorporated into a model to determine seasonality.

(8) $Y\ (SNF) = a + B_1\ (Season) + e$

The designated seasons were composed of the following months:

Season 1 - Winter - (December, January, and February)
2 - Spring - (March, April, and May)
3 - Summer - (June, July, and August)
4 - Autumn - (September, October, and November)

The seasons were composed of the above months to more nearly coincide with the milk production season, and consumption and production patterns, rather than using the more standard calendar seasons.

The results of the season model are presented in Table 13. The intercept value (8.6058) is the overall SNF mean value without any seasonality. The dummy coefficients and their significance levels indicate if the individual seasons vary significantly from the overall average. The above results show that season 1 is significantly above the average, season 2 is not significantly different from the average, while season 3 is significantly below the average, and season 4 is significantly higher than the average.

Next, Duncan's multiple range test was used to determine if the means of the seasons were significantly different from each other.

Table 13. Results of the Regression Equation: SNF = a + B_1 (Season)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	3	0.4696	0.1565	54.3840	.0001
Error	116	0.3339	0.0029		R-Square
Total	119	0.8034			.5845

Source	B Values	T for H0:B=0	Probability T
Intercept	8.6058	1757.2096	.0001
Dummy 1	0.0637	7.5148	.0001
Dummy 2	0.0138	1.6315	.1055
Dummy 3	- 0.1036	- 12.2078	.0001
Dummy 4	0.0260	3.0615	.0027

$$w = q_{(p,n_2)} \, S_{\bar{x}}$$

q = obtained from statistics tables
p = # of treatments
n_2= error degrees of freedom

$$S_{\bar{x}} = \sqrt{\frac{\text{MSE}}{\text{r}}\;\begin{matrix}\text{(mean square error)}\\ \text{(\# of observations/}\\ \text{mean)}\end{matrix}} = \sqrt{\frac{.00287814}{30}} = \sqrt{.000095938} = .0097948$$

Value of p		2	3	4
SSR (q)	5%	2.77	2.92	3.02
(from tables)	1%	3.64	3.80	3.90
LSR (w)	5%	.0271	.0286	.0296
(SSR x $S_{\bar{x}}$)	1%	.0357	.0372	.0382

Season means ranked in order from lowest to highest:

Season 3	Season 2	Season 4	Season 1
8.5022	$\underline{8.6196}$	$\underline{8.6318}$	8.6695

The means are then subtracted in the following manner: highest minus lowest (#1-#3), highest minus next lowest (#1-#2), highest minus next lowest (#1-#4), then third highest minus lowest (#4-#3), etc. If these differences are greater than the numbers in the LSR column, then the seasons are significantly different. Seasons that are not significantly different are underlined. All means were significantly different at the 5 percent and 1 percent levels except seasons 2 and 4.

The dummy variable approach was likewise applied to the butterfat data for seasonal differences, using the model below.

$$(9) \quad Y\ (BF) = a + B_1\ (\text{Season}) + e$$

The results of the season model are presented in Table 14. The intercept value (3.5957) is the overall butterfat mean without any seasonality effects. The dummy variables again indicate whether or not

Table 14. Results of the Regression Equation: $BF = a + B_1$ (Season)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	3	1.9539	0.6513	78.1253	.0001
Error	116	0.9670	0.0083		R-Square
Total	119	2.9209			.6689

Source	B Values	T for H0:B=0	Probability T
Intercept	3.5957	431.3952	.0001
Dummy 1	0.1657	11.4755	.0001
Dummy 2	- 0.0873	- 6.0494	.0001
Dummy 3	- 0.1553	- 10.7597	.0001
Dummy 4	.0770	5.3337	.0001

the seasons vary significantly from the overall mean. The above results show that seasons 1 and 4 are significantly above the average, while seasons 2 and 3 are significantly below the average. This shows that butterfat in milk runs below average from March through August and above average from September through February.

Duncan's multiple range test was again used to determine if the season means were significantly different from each other.

$$w = q_{(p,n_2)} \, S_{\bar{x}}$$

$$S_{\bar{x}} = \sqrt{\frac{MSE}{r} \begin{array}{l}\text{(mean square error)}\\ \text{(\# of observations/}\\ \text{mean}\end{array}} = \sqrt{\frac{.00833661}{30}} = \sqrt{.000277887} = .016669943$$

Value of p		2	3	4
SSR (q)	5%	2.77	2.92	3.02
(from tables)	1%	3.64	3.80	3.90
LSR (w)	5%	.0462	.0486	.0503
(SSR x $S_{\bar{x}}$)	1%	.0606	.0633	.0650

Means ranked in order from lowest to highest:

Season 3	Season 2	Season 4	Season 1
3.44	3.51	3.67	3.76

The results show that all season means are significantly different from each other.

The correlation coefficient between SNF and butterfat is .7536, indicating a strong relationship between the two variables. The trend lines (graphs) indicating changes by seasons show that the movements of the two components are directly related, but the variations are more pronounced in butterfat, Figures 1 and 2.

To further accomplish the requirements of the first objective, the three years of data (1972-1974) containing protein content of milk were analyzed to determine relationships between protein (Pro), SNF, and butterfat.

The first two equations were as follows:

(10) $Y\ (PRO) = a + B_1\ (Butterfat) + e$

(11) $Y\ (PRO) = a + B_1\ (SNF) + e$

The following results were obtained for Model 10.

$$\underset{(4.4479)}{Pro = 1.1707} + \underset{(7.7009)}{.5729\ BF}$$

The coefficient for butterfat was significant at the .0001 level. The overall F (59.3037) for the linear expression was significant beyond the 1 percent level, and R^2 was .6615, indicating that two-thirds of the protein variation can be explained by the BF. The correlation coefficient (r) is .7972, indicating a strong relationship between protein and butterfat. The overall mean for protein was 3.1958.

The following results were obtained for Model 11.

$$Pro = \underset{(-6.5959)}{-6.2810} + \underset{(9.9524)}{1.1031}$$

The coefficient for SNF was significant at the .0001 level. The overall F (99.0500) was significant beyond the 1 percent level. The R^2 (.7445) was higher for Model 11 than Model 10, indicating that SNF is a better indicator of protein than is butterfat. The correlation

Figure 1. Average Content of SNF and BF in Producer Milk by Month

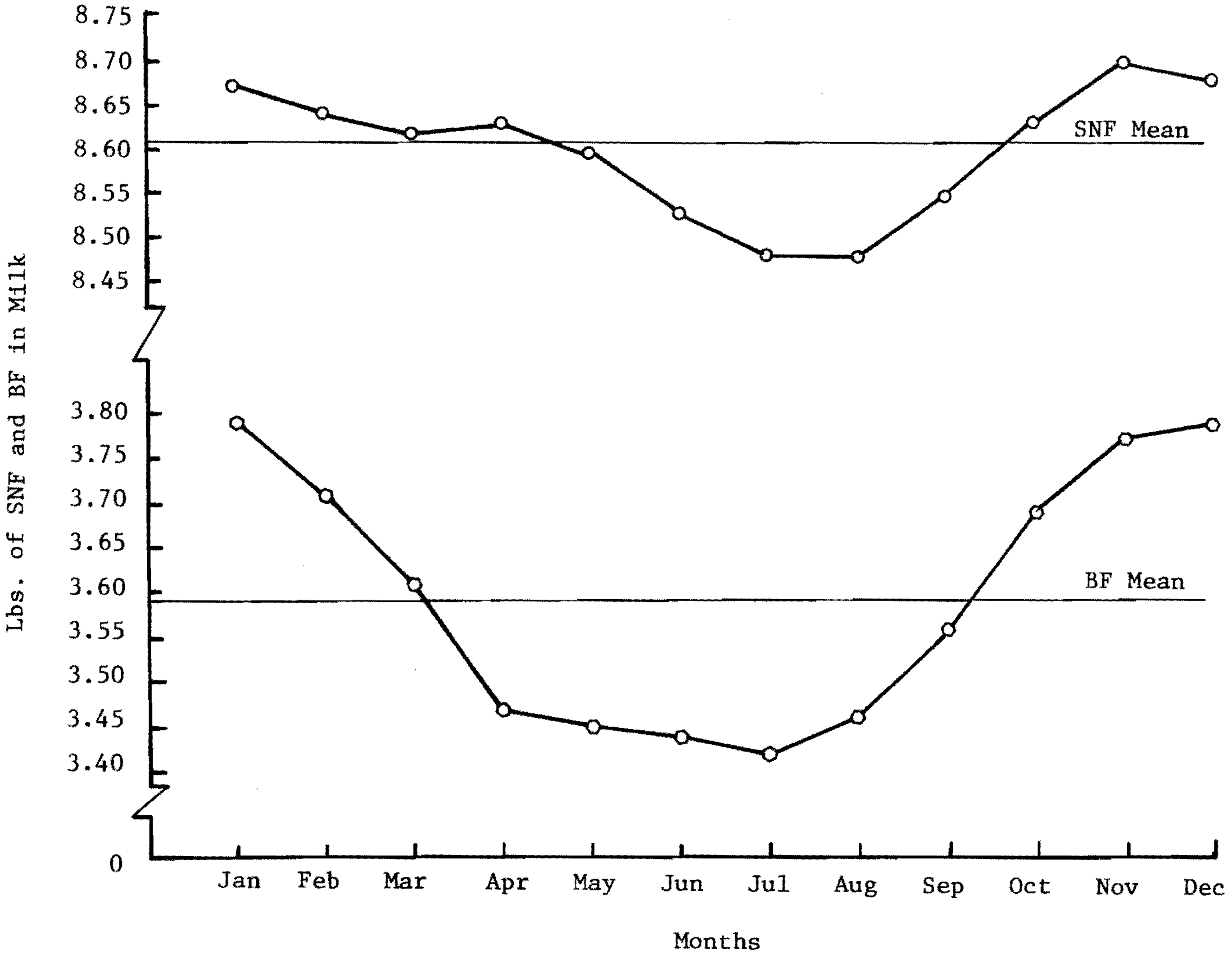
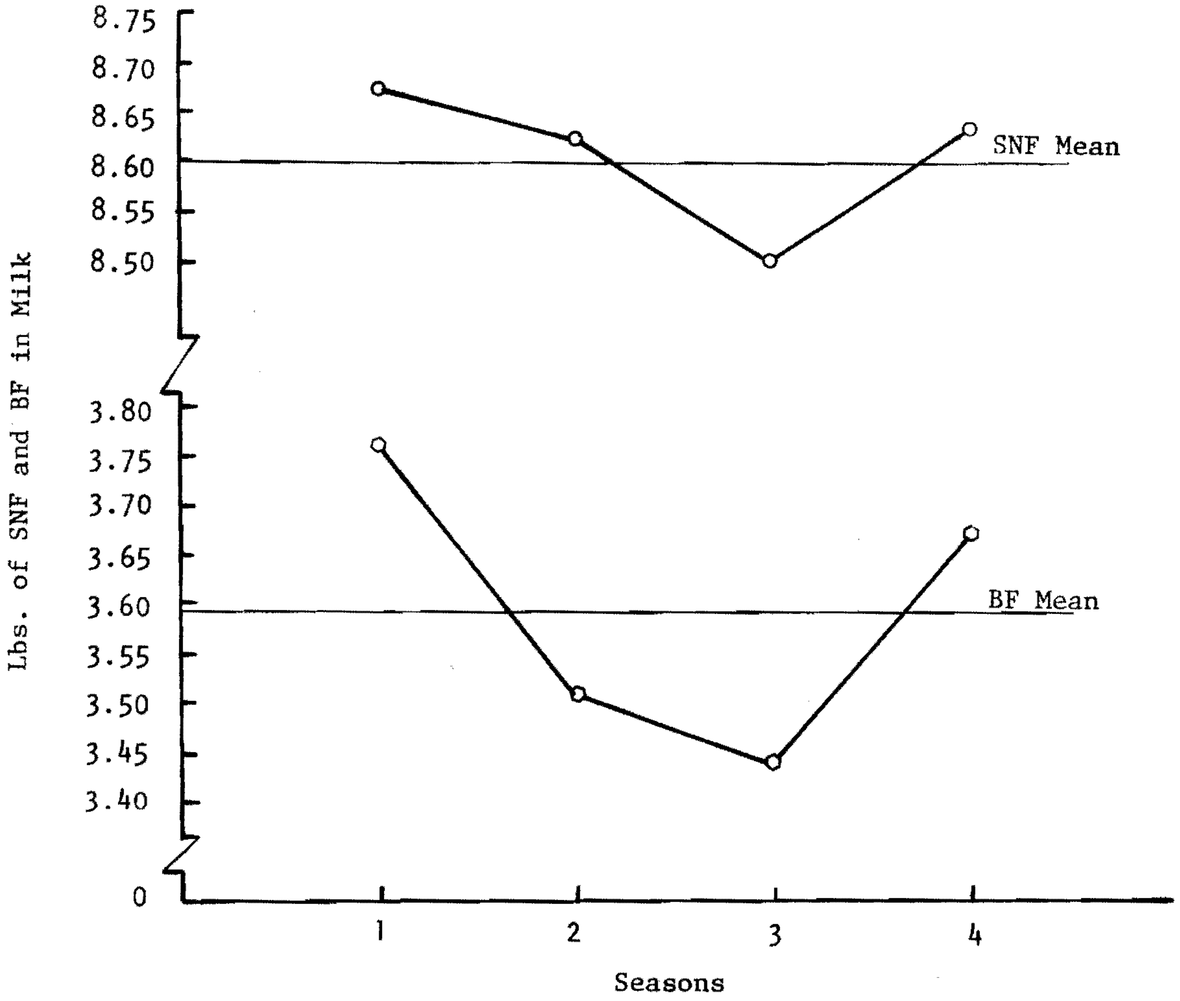


Figure 2. Average Content of SNF and BF in Producer Milk by Season



coefficient (.8628) between protein and SNF was also higher than for protein and butterfat. This was expected since protein is a component of SNF.

The mean values for SNF and butterfat for the 36 months decreased, as was expected from earlier computations. The SNF mean value for January, 1972 through December, 1974 was 8.5913 compared to 8.6058 for the 10-year period. The butterfat mean value dropped from 3.5957 to 3.5347.

Since there were only three years of data, no equations were fitted using time in years as a variable. However, there was a sufficient number of observations to test for seasonality. The first model used was:

$$(12) \quad Y\ (PRO) = a + B_1\ (Month) + e$$

The results for Model 12 are found in Table 15. The model has an F value of 4.2454 which is significant at the 1 percent level, and the R^2 (.6605) is relatively high. The intercept (3.1958) is the overall protein mean value. The T and probability values show that protein levels in November are significantly higher at the 1 percent level than the average. Protein levels in July are significantly lower while in the remaining months the protein levels are not significantly different from the average.

The remaining model used to test for seasonality was:

$$(13) \quad Y\ (PRO) = a + B_1\ (Season) + e$$

The results for Model 13 are shown in Table 16. Again, this equation shows whether the seasons are significantly different from the

Table 15. Results of Regression Equation: PRO = a + B_1 (Month)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	11	0.2855	0.0260	4.2454	.0018
Error	24	0.1467	0.0061		R-Square
Total	35	0.4323			.6605

Source	B Values	T for H0:B=0	Probability T
Intercept	3.1958	245.2209	.0001
Dummy 1	0.0845	1.9539	.0625
Dummy 2	0.0172	0.3986	.6938
Dummy 3	- 0.0318	- 0.7357	.4690
Dummy 4	- 0.0169	- 0.3917	.6987
Dummy 5	- 0.0476	- 1.1019	.2814
Dummy 6	- 0.1166	- 2.6967	.0126
Dummy 7	- 0.1290	- 2.9851	.0064
Dummy 8	- 0.1051	- 2.4308	.0229
Dummy 9	- 0.0100	- 0.2324	.8182
Dummy 10	0.0992	2.2954	.0308
Dummy 11	0.1369	3.1669	.0042
Dummy 12	0.1193	2.7597	.0109

Table 16. Results of Regression Equation: PRO = a + B_1 (Season)

Source	DF	Sum of Squares	Mean Square	F Value	Probability F
Regression	3	0.2322	0.0774	12.3754	.0001
Error	32	0.2001	0.0063		R-Square
Total	35	0.4323			.5371

Source	B Values	T for HO:B=0	Probability T
Intercept	3.1958	242.4780	.0001
Dummy 1	0.0737	3.2265	.0029
Dummy 2	- 0.0321	- 1.4070	.1691
Dummy 3	- 0.1169	- 5.1202	.0001
Dummy 4	0.0754	3.3008	.0024

overall mean for protein. Seasons 1 and 4 are significantly higher than the average, season 3 is significantly lower, and season 2 is not significantly different. This means that milk has a higher protein content in fall and winter, and as was the case with the other components, the protein level drops below average in spring and summer.

Once more, Duncan's multiple range test was used to determine if the means of the seasons were significantly different from each other.

$$w = q_{(p,n_2)} S_{\bar{x}}$$

$$S_{\bar{x}} = \sqrt{\frac{MSE}{r} \begin{array}{l}\text{(mean square error)}\\ \text{(\# of observations/}\\ \text{mean)}\end{array}} = \sqrt{\frac{.00625352}{9}} = \sqrt{.0006948} = .026359$$

Value of p		2	3	4
SSR (q)	5%	2.89	3.04	3.12
(from tables)	1%	3.88	4.05	4.15
LSR (w)	5%	.0762	.0801	.0822
(SSR x $S_{\bar{x}}$)	1%	.1023	.1068	.1094

The means were ranked from lowest to highest:

	Season 3	Season 2	Season 1	Season 4
5% level	3.0789	3.1637	3.2695	3.2712
1% level	3.0789	3.1637	3.2695	3.2712

At the 5 percent of significance, all seasons were significantly different except seasons 4 and 1. At the 1 percent level, seasons 2 and 3 and seasons 4 and 1 were not significantly different from each other.

The trend lines (graphs) show that all three components are directly related, with butterfat having the most pronounced variation, Figures 3 and 4.

Figure 3. Average Content of SNF, BF, and PRO in Producer Milk by Month

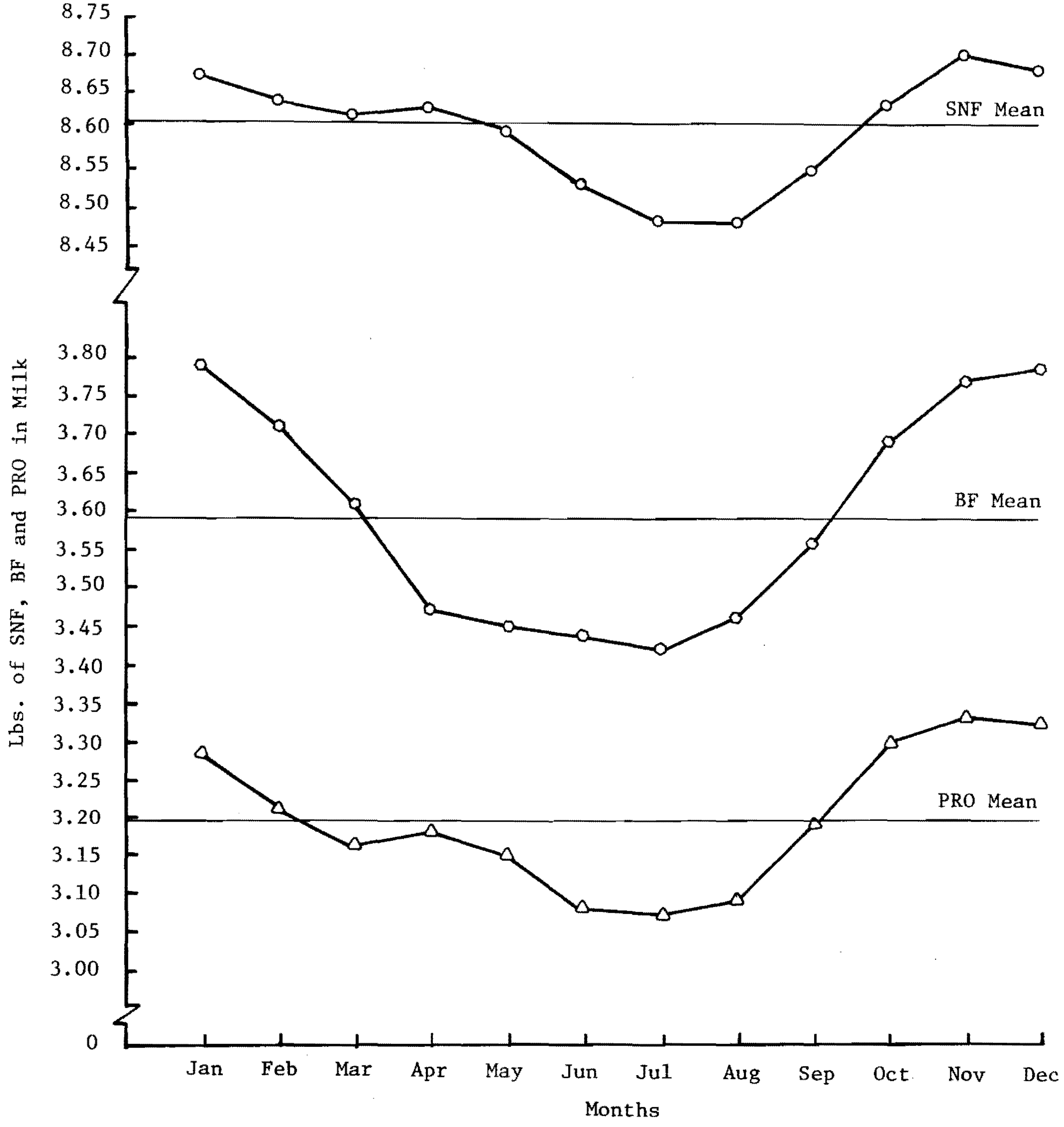
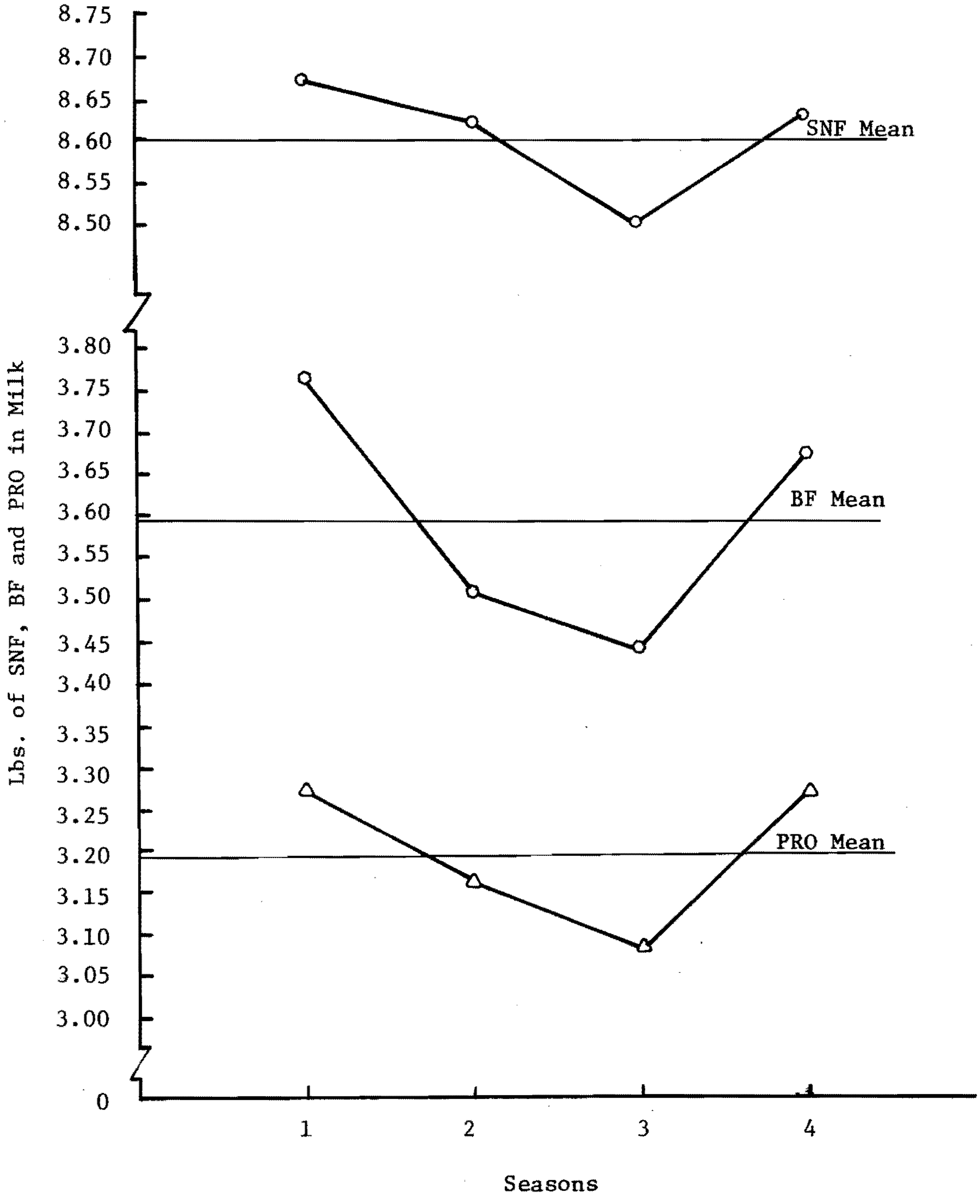


Figure 4. Average Content of SNF, BF, and PRO in Producer Milk by Seasons



However, the means for SNF and BF are for the entire 10 years, while the protein means represent only the 3-year period, and some small differences would result in using the 3-year period for SNF and BF.

CHANGES IN COMPONENT VALUES AND PRICE DIFFERENTIALS

Changes in Value of Milk Components

Earlier in this study, discussion was centered around the incentive for the producer to produce large volumes of milk with as high a butterfat content as economically feasible. Producers, milk market administrators, and processors usually keep a close account of butterfat pounds from their receipt through their disposition, while very little accounting is done for the remaining components. In the meantime, values for the other components have risen due to shifts in consumer demand as evidenced by falling consumption of butter, cream and other high fat products, and rising consumption of low-fat milk, skim milk, yogurt, and other low-fat products. This trend lends itself to speculation that possible additional profits may have accrued to processors at the expense of producers, without either party being fully aware of the situation.

The data in Tables 1 and 2 explicitly show what has occurred in the relative price and value of SNF and butterfat. The average Class I price has risen by 84 percent (from $5.20 to $9.58) over the 10-year period, 1965-1974, while the Class II price increased by 124 percent, or from $3.086 in 1965 to $6.902 in 1974. Meanwhile, the Class I and Class II butterfat differentials remained relatively stable throughout the 10 years. The Class I differential averaged 8.3 cents per .1 percent butterfat and ranged from 7.5 to 8.7 cents during this period. The Class II differential has averaged 7.6 cents per .1 percent butterfat, and ranged from

6.0 to 8.0 cents. Since September 1, 1974, the same differential has been used for both classes and has averaged 7.8 cents since that time.

With the rise in prices and the butterfat differential remaining relatively steady, the relative value of butterfat in milk has dropped rather drastically. As is indicated in Table 2, in 1965, 3.5 pounds of butterfat in 100 pounds of milk used in Class I was worth 50.5 percent of the total value of the 100 pounds. In 1974 this value had dropped by 21.3 percent of total value so that the butterfat in the milk was worth only 29.2 percent of the value. Meanwhile the skim, or residual value, increased by 21.3 percent of the total value, or from 49.5 percent to 70.8 percent of the total value. The changes in value were even more dramatic in the Class II prices and values. In 1965 the butterfat accounted for 78.3 percent of the total value of Class II milk while the residual accounted for 21.7 percent of the total value. In 1974 the situation had nearly reversed with butterfat accounting for 38.0 percent of the value while the skim value had risen to 62 percent, a change of 40.3 percent of total value.

With the change in consumer demand and the drastic realignment in residual prices and values, a need exists for development of an alternative pricing proposal to compensate producers for the residual components of milk. The remainder of this study is directed toward development of a protein, or SNF differential that could be incorporated into the present pricing procedure with a minimum amount of disruption.

A Hypothetical SNF Differential

In introducing and developing a SNF differential into the present pricing procedure, three main factors must be determined. First, should the problem revolve around the redistribution of funds with the same total amount of funds in the pool, or should a differential be established that may change the total value of the pool? Second, where should the standard level of SNF be set? Third, what price should be established per point of SNF for deviations above and below the standard level?

In the dairy industry a "point" is referred to as one-tenth of 1 percent, or one-tenth of 1 pound of butterfat. The butterfat differential is the adjustment in price for each point of butterfat above or below the standard level. For this example a price must be established for each point of SNF, and it will represent one-tenth of 1 percent SNF.

The standard level of SNF to correspond with the 3.5 percent level of butterfat was obtained from the regression equation $SNF = a + B_1 (BF)$. From the equation, 8.5719 was obtained as the average level of SNF in milk containing 3.5 percent butterfat. This figure (8.5719) is slightly higher than the one used by Hillers, _et_ _al_., in his study. If the average butterfat content of milk continues to decline, this standard level may need to be revised again in the future.

In establishing a price for deviations in the SNF level, the average annual Chicago wholesale prices for butter and nonfat powder from 1965-1974 were used. These prices are presented in Table 17.

Table 17. Average Annual Chicago Wholesale Prices for Butter and Nonfat Powder - 1965 - 1974

Year	Nonfat Dry Milk (Human Consumption)	Butter
	Cents Per Pound	
1965	14.7	60.2
1966	18.2	N.A.
1967	19.9	66.7
1968	22.4	66.9
1969	23.5	66.7
1970	26.3	69.4
1971	30.7	68.4
1972	32.7	68.6
1973	46.4	69.8
1974	58.6	65.3

Source: 1974 Annual Summary of Agricultural Statistics.

In setting a value for the SNF differential, the proper value to use should be related to the true market value of the nonfat solids. However, the true market value of milk components is only speculative because the totally free enterprise, perfectly competitive situation does not exist today in the dairy industry. The government support program, through which large volumes of butter, powder, and cheese are purchased by the Commodity Credit Corporation, keeps the prices of these commodities artificially high. However, these government-influenced prices are the only market prices available, and they are, therefore, used in the example.

(1) Using 1974 class prices, the blend price paid to producers is calculated on the basis of a 70 percent Class I utilization, along with the blend butterfat differential.

Class I		Class II			
\$9.58		\$6.902			
x .70		x .30			
\$6.7060	+	\$2.0706	=	\$8.7766	Blend price per 100 lbs. at 3.5% BF

8.0¢/.1 BF for Class I		7.5¢/.1 BF for Class II		
x .70		x .30		
5.6¢	+	2.25¢	=	7.85¢/.1 BF Blend BF differential

Producers delivering milk containing 4.0; 3.5; and 3.0 percent butterfat would receive the following prices per 100 pounds of milk.

Producer	(a)	4.0% BF	Price = 8.7766 + .3925 = \$9.1691
Pay	(b)	3.5%	Price = 8.7766 = 8.7766
Prices	(c)	3.0%	Price = 8.7766 - .3925 = 8.3841

(2) Removing the butterfat value from the blend prices at the respective butterfat levels produces the following skim values:

(a)	(b)	(c)
7.85¢/.1 BF	7.85¢/.1 BF	7.85¢/.1 BF
x 40	x 35	x 30
\$3.14 BF value	\$2.7475 BF value	\$2.355 BF value

(a) \$9.1691 - blend price for 4.0% BF milk
-3.14 - value of 4.0 lbs. of butterfat
\$6.0291 - value of 96 lbs. skim

(b) \$8.7766 - blend price for 3.5% of BF milk
-2.7475 - value of 3.5 lbs. of butterfat
\$6.0291 - value of 96.5 lbs. skim

(c) \$8.3841 - blend price for 3.0% BF milk
-2.355 - value of 3.0 lbs. of butterfat
\$6.0291 - value of 97 lbs. skim

(3) Dividing the skim values by the pounds of skim, yields the skim price per pound.

(a) \$6.0291 ÷ 96 = \$.06280 per pound
(b) \$6.0291 ÷ 96.5 = \$.06248 per pound
(c) \$6.0291 ÷ 97 = \$.06216 per pound

Therefore, under the present pricing procedure, producers are paid basically the same for the skim portion of their milk regardless of its content.

The inequity in the present system can be further illustrated by placing a value on the SNF according to content. The regression equation obtained earlier in this study yielded the following:

SNF = 7.3325 + .3541 (BF). This yields the following SNF values:

(a) 4.0% BF SNF = 8.7489 lbs.
(b) 3.5% BF SNF = 8.5719 lbs.
(c) 3.0% BF SNF = 8.3948 lbs.

Arbitrarily using 5¢/.1 SNF yields the following values:

(a) 8.7489 x .05¢/.1 = \$4.3745
(b) 8.5719 x .05¢/.1 = \$4.2860
(c) 8.3948 x .05¢/.1 = \$4.1974

By removing these SNF values from the skim values obtained in (2) above, the following results:

(a)	(b)	(c)
$6.0291	$6.0291	$6.0291
-4.3745	-4.2860	-4.1974
$1.6546	$1.7431	$1.8317

In the above example, three farmers each producing 100 pounds of milk with a butterfat content of 4.0 percent, 3.5 percent, and 3.0 percent respectively would be paid $9.1691, $8.7766, and $8.3841. If the total butterfat value as well as the average SNF value at 5¢/.1 SNF are removed, the residuals that are left are quite different. This means that the three farmers are in effect paid three different prices ($1.6546 @ 4.0 percent BF; $1.7431 @ 3.5 percent; and $1.8317 @ 3.0 percent) for the water, or fluid portion of their milk.

Using the 1974 class prices with the 70 percent Class I utilization again yields the $8.7766 blend price with a 7.85¢/.1 BF differential for butterfat. By adding a 5¢/.1 SNF differential and establishing the standard for SNF at 8.5719, the following prices result:

		Present Blend	New Price						
BF	SNF	Price	Blend		BF Dif.		SNF Dif.		Price
4.0%	8.9260	$9.1691	$8.7766	+	.3925	+	.1771	=	$9.3462
4.0%	8.7489	9.1691	8.7766	+	.3925	+	.0885	=	9.2576
4.0%	8.5719	9.1691	8.7766	+	.3925	+	.00	=	9.1691
3.5%	8.7489	8.7766	8.7766	+	0	+	.0885	=	8.8651
3.5%	8.5719	8.7766	8.7766	+	0	+	.00	=	8.7766
3.5%	8.3948	8.7766	8.7766	+	0	-	.0885	=	8.6881
3.0%	8.5719	8.3841	8.7766	-	.3925	-	.00	=	8.3841
3.0%	8.3948	8.3841	8.7766	-	.3925	-	.0885	=	8.2956
3.0%	8.2178	8.3841	8.7766	-	.3925	-	.1771	=	8.2070

New Price	-	BF Value	-	SNF Value	=	Value of Fluid Carrier
$9.3462	-	$3.14	-	$4.4630	=	$1.7432
9.2576	-	3.14	-	4.3745	=	1.7431
9.1691	-	3.14	-	4.2860	=	1.7431
8.8651	-	2.7475	-	4.3745	=	1.7431
8.7766	-	2.7475	-	4.2860	=	1.7431
8.6881	-	2.7475	-	4.1974	=	1.7432
8.3841	-	2.355	-	4.2860	=	1.7431
8.2956	-	2.355	-	4.1974	=	1.7432
8.2070	-	2.355	-	4.1089	=	1.7431

Under this new pricing procedure, a producer would be compensated not only for the butterfat content of his milk, but also for the more valuable SNF component. All producers would be paid the same residual value for the least valuable component of milk, the water or fluid portion. However, since SNF and butterfat have a strong direct relationship, the producer with a high fat test would be economically favored while a producer with a low-fat test would be at a disadvantage compared to the present pricing procedure.

Concern was expressed earlier in this study that a new formula be introduced with the least amount of disruption, yet the total value of the pool was allowed to fluctuate so as not to have a reallocation problem. In 1973, a total of 1,386,374,000 pounds of milk was marketed under the North Texas Federal Order. Using the 1973 average yearly class prices with a 70 percent Class I utilization, this milk would have amounted to $105,756,767 being paid by handlers and distributed to producers. If the above SNF differential had been in effect and priced at 4 cents per point, the pool would have been enlarged by only $12,311, an insignificant amount. In 1974, a total of 1,628,899,000 pounds of milk was marketed under the North Texas Order. Using the 1974 class prices with a 70 percent utilization, $143,217,687 would have been distributed to producers. With a 5 cents per point SNF differential, this total would have been lowered by $4,805. This is because the annual average SNF content in 100 pounds of producer milk delivered on the North Texas market in 1974 amounted to 8.566 pounds versus 8.592 in 1973 and the standard of 8.572 pounds. This was the only year (out of the 10 years of data analyzed) that the SNF content was below the standard of 8.572 established in this study.

A Hypothetical Protein Differential

Another alternative in component pricing is to establish a protein differential rather than the SNF differential. Protein accounts for approximately 37 percent of the solids-not-fat of milk and is the most variable part of the solids-not-fat (Table 6). Protein is a very important component of milk since over 20 percent of the protein in the diet of the average United States citizen comes from milk. Protein is increasing in importance and a large part of the rise in the price of SNF over the past few years can be attributed to protein.

In developing a protein differential, the same three factors that were determined for the SNF differential must also be determined for protein. They are:

1. Should the total value of the pool be allowed to fluctuate?
2. Where should the standard level of protein be set?

3. What price should be established per point of protein for deviations above and below the standard level?

In this study the total value of the pool was allowed to fluctuate. The standard level of protein was determined from the regression equation: $Pro = a + B_1 (BF)$. The standard level to correspond with a 3.5 percent BF content is 3.1759 pounds of protein. The price of protein was arbitrarily set at 4 cents per point of protein. This price was determined by arbitrarily taking 80 percent of the average wholesale price for nonfat dry milk at Chicago in 1974, minus 6.88 cents per pound processing margin.

Using the 1974 blend price of $8.7766 per hundredweight with a 7.85 cents per point BF differential and adding a 4 cents per point protein differential resulted in the following prices:

BF	Protein	Present Price	Blend Price		BF Diff.		Pro. Diff.		New Price
4.0%	3.7488	$9.1691	$8.7766	+	$.3925	+	$.2292	=	$9.3983
4.0%	3.4623	9.1691	8.7766	+	.3925	+	.1146	=	9.2837
4.0%	3.1759	9.1691	8.7766	+	.3925	+	0	=	9.1691
3.5%	3.4623	8.7766	8.7766	+	0	+	.1146	=	8.8912
3.5%	3.1759	8.7766	8.7766	+	0	+	0	=	8.7766
3.5%	2.8894	8.7766	8.7766	+	0	-	.1146	=	8.6620
3.0%	3.1759	8.3841	8.7766	-	.3925	-	0	=	8.3841
3.0%	2.8894	8.3841	8.7766	-	.3925	-	.1146	=	8.2695
3.0%	2.6030	8.3841	8.7766	-	.3925	-	.2292	=	8.1549

If the values for BF at 7.85 cents per point and protein at 4 cents are removed, inequities in the residual values are again eliminated as in the SNF example. This is indicated in the following example:

New Price	-	BF Diff.	-	Pro. Diff.	=	Residual Value
$9.3983	-	$3.14	-	$1.4995	=	$4.7588
9.2837	-	3.14	-	1.3849	=	4.7588
9.1691	-	3.14	-	1.2704	=	4.7587
8.8912	-	2.7475	-	1.3849	=	4.7588
8.7766	-	2.7475	-	1.2704	=	4.7587
8.6620	-	2.7475	-	1.1558	=	4.7587
8.3841	-	2.355	-	1.2704	=	4.7587
8.2695	-	2.355	-	1.1558	=	4.7587
8.1549	-	2.355	-	1.0412	=	4.7587

Protein and butterfat contents have a strong direct relationship, as do SNF and butterfat. The high fat milk producer would again be economically favored while the low-fat producer would be at a disadvantage with a protein differential pricing method compared to the present pricing procedure.

There is relatively little difference in the blend prices when comparing the SNF, or protein differential examples. However, in the protein example the residual value has been greatly increased because the butterfat and protein differentials account for less total solids than do the butterfat and SNF differentials.

Differential with a Decreased Butterfat Value

The direct relationship between BF and SNF was evident throughout the preceding examples on component differentials and the fact remains that as protein or SNF contents rise, butterfat also rises. This occurs because of the very nature of the milk cow. Yet, it has been emphasized that the value of butterfat has remained relatively stable, butter consumption per capita is continually declining, and the government continues to purchase large quantities of butter to keep the price artificially high. Conversely, the nonfat values have gained importance over the past 10 years and consumption has risen as has the price. The examples of component differential in pricing economically favor the high fat producers. If these differentials were put into effect, producers would probably tend to emphasize a butter fat increase knowing that nonfat increase would automatically accompany the butterfat increase.

One possible means of remedying this situation could be to lower the butterfat differential and increase the SNF differential. This would place an incentive on testing, selecting, and breeding milk producing animals with a low fat content and a high nonfat content.

Using the relationships given by the regression equation $SNF = 7.3325 + .3541\ BF$, SNF rises by .3541 units when BF rises by one unit. Therefore, as SNF rises by 1.0, BF rises 2.824. In order to keep the total blend price and the residual price for the fluid carrier the same as under the present pricing procedure, 2.824 cents per point of SNF must be added for each 1.0 cent per point decrease in the butterfat differential price. This relative change in price holds for any value as long as the basic relationships between the components remain as determined in the regression equations.

The following is an example of the effect on price of changing BF and SNF differentials:

	BF Content	SNF Content		BF Diff.	SNF Diff.	
Present Price	4.0	8.7489	$8.7766 +	$.3925 (.0785 x 5)	+ 0	= $9.1691
New Price with lower BF diff. and added SNF differential	4.0	8.7489	8.7766 +	.3425 (.0685 x 5)	+ .0500 (.02824 x 1.77)	= 9.1691
Present Price	3.5	8.5719	8.7766 +	0	+ 0	= 8.7766
Present Price	3.0	8.3948	8.7766 -	.3925 (.0785 x 5)	- 0	= 8.3841
New Price with lower BF diff. and added SNF differential	3.0	8.3948	8.7766 -	.3425 (.0685 x 5)	- .0500 (.02824 x 1.77)	= 8.3841

To keep the prices the same, the differential values below would be used:

BF	SNF
--- (cents per .1 pound) ---	
7.85	0
6.85	2.824
5.85	5.648
4.85	8.472
3.85	11.296

Likewise, the increase in protein value needed to offset a decrease in butterfat value is calculated. Through regression, the relationship was calculated to be Pro = 1.1707 + .5729 (BF). As butterfat rises by one unit, protein rises by .5729 units. Therefore, when protein rises by one unit, butterfat rises by 1.746 units. To keep the total blend price the same as under the present system, 1.746 cents per point of protein must be added for each 1 cent per point decrease in the butterfat differential. This is shown in the following example:

	BF Content	Protein Content		BF Diff.	Pro. Diff.	
Present Price	4.0	3.4623	$8.7766 +	$.3925 + (.0785 x 5)	$0	= $9.1691
Price with lower BF differential and added Protein differential	4.0	2.4623	8.7766 +	.3425 + (.0685 x 5)	.0500 (.01746 x 2.864)	= 9.1691
Present Price	3.5	3.1759	8.7766 +	0 +	0	= 8.7766
Present Price	3.0	2.8894	8.7766 -	.3925 - (.0785 x 5)	0	= 8.3841
Price with lower BF differential and added Protein differential	3.0	2.8894	8.7766 +	.3425 - (.0685 x 5)	.0500 (.01746 x 2.864)	= 8.3841

To again keep the price the same, the following differentials derived from the 1.746:1 ratio would be used if the butterfat values are lowered:

BF	Protein
--- (cents per .1 pound) ---	
7.85	0
6.85	1.746
5.85	3.492
4.85	5.238
3.85	6.984

A simplified calculation of the values of nonfat solids in producer milk at varying SNF prices and content is presented in Table 18. From these values, hypothetical differentials, using 8.500 as the SNF standard, were calculated and are presented in Table 19.

Table 18. Value of SNF in Producer Milk at Varying Prices and Content

SNF (Lbs./Cwt.)	Price of SNF Per Pound						
	40¢	45¢	50¢	55¢	60¢	65¢	70¢
	--------dollar value per cwt. of milk--------						
8.00	3.20	3.60	4.00	4.40	4.80	5.20	5.60
8.05	3.22	3.62	4.03	4.43	4.83	5.23	5.64
8.10	3.24	3.65	4.05	4.46	4.86	5.27	5.67
8.15	3.26	3.67	4.08	4.48	4.89	5.30	5.71
8.20	3.28	3.69	4.10	4.51	4.92	5.33	5.74
8.25	3.30	3.71	4.13	4.54	4.95	5.36	5.78
8.30	3.32	3.74	4.15	4.57	4.98	5.40	5.81
8.35	3.34	3.76	4.18	4.59	5.01	5.43	5.85
8.40	3.36	3.78	4.20	4.62	5.04	5.46	5.88
8.45	3.38	3.80	4.23	4.65	5.07	5.49	5.92
8.50	3.40	3.83	4.25	4.68	5.10	5.53	5.95
8.55	3.42	3.85	4.28	4.70	5.13	5.56	5.99
8.60	3.44	3.87	4.30	4.73	5.16	5.59	6.02
8.65	3.46	3.89	4.33	4.76	5.19	5.62	6.06
8.70	3.48	3.92	4.35	4.79	5.22	5.66	6.09
8.75	3.50	3.94	4.38	4.81	5.25	5.69	6.13
8.80	3.52	3.96	4.40	4.84	5.28	5.72	6.16
8.85	3.54	3.98	4.43	4.87	5.31	5.75	6.19
8.90	3.56	4.01	4.45	4.89	5.34	5.79	6.23
8.95	3.58	4.03	4.48	4.92	5.37	5.82	6.27
9.00	3.60	4.05	4.50	4.95	5.40	5.85	6.30

Table 19. Hypothetical SNF Differentials at Varying Prices, Using a Standard SNF Content of 8.50

SNF (Lbs./Cwt.)	Price of SNF Per Pound						
	40¢	45¢	50¢	55¢	60¢	65¢	70¢
8.00	- .2000	- .2250	- .2500	- .2750	- .3000	- .3250	- .3500
8.05	- .1800	- .2025	- .2250	- .2475	- .2700	- .2925	- .3150
8.10	- .1600	- .1800	- .2000	- .2200	- .2400	- .2600	- .2800
8.15	- .1400	- .1575	- .1750	- .1925	- .2100	- .2275	- .2450
8.20	- .1200	- .1350	- .1500	- .1650	- .1800	- .1950	- .2100
8.25	- .1000	- .1125	- .1250	- .1375	- .1500	- .1625	- .1750
8.30	- .0800	- .0900	- .1000	- .1100	- .1200	- .1300	- .1400
8.35	- .0600	- .0675	- .0750	- .0825	- .0900	- .0975	- .1050
8.40	- .0400	- .0450	- .0500	- .0550	- .0600	- .0650	- .0700
8.45	- .0200	- .0225	- .0250	- .0275	- .0300	- .0325	- .0350
8.50	0	0	0	0	0	0	0
8.55	+ .0200	+ .0225	+ .0250	+ .0275	+ .0300	+ .0325	+ .0350
8.60	+ .0400	+ .0450	+ .0500	+ .0550	+ .0600	+ .0650	+ .0700
8.65	+ .0600	+ .0675	+ .0750	+ .0825	+ .0900	+ .0975	+ .1050
8.70	+ .0800	+ .0900	+ .1000	+ .1100	+ .1200	+ .1300	+ .1400
8.75	+ .1000	+ .1125	+ .1250	+ .1375	+ .1500	+ .1625	+ .1750
8.80	+ .1200	+ .1350	+ .1500	+ .1650	+ .1800	+ .1950	+ .2100
8.85	+ .1400	+ .1575	+ .1750	+ .1925	+ .2100	+ .2275	+ .2450
8.90	+ .1600	+ .1800	+ .2000	+ .2200	+ .2400	+ .2600	+ .2800
8.95	+ .1800	+ .2025	+ .2250	+ .2475	+ .2700	+ .2925	+ .3150
9.00	+ .2000	+ .2250	+ .2500	+ .2750	+ .3000	+ .3250	+ .3500

SELECTED REFERENCES

Hillers, J. K. *et al*. "Effects of 17 Milk Pricing Systems," *Journal of Dairy Science*, 54:187-190, February 1971.

Jacobsen, Robert E. "Higher Fat Differentials but Lower Pool Prices," *Ohio Co-operative Extension Service Milk Marketeer #15*, October 1974.

Johnson, Stewart. "Experiences with and Suggestions for Multiple Component Pricing Plans," *Proceeding--Western Dairy Conference Symposium*, March 1971.

Luke, H. Alan. "Multiple Component Pricing--Why Be Concerned," *Proceedings--Western Dairy Conference Symposium*, March 1971.