Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 2 *Dairy Research (1984-2014)*

Article 332

1995

Inclusion of fat in diets for early lactating holstein cows

Michael V. Scheffel

John E. Shirley

Inclusion of fat in diets for early lactating holstein cows

Abstract

Twenty-four Holstein cows were used to study the effect of dietary fat on milk production and metabolic traits. Whole cottonseed and tallow were used as fat sources and substituted into the control diet on an isocaloric basis. Chopped alfalfa hay and grain sorghum silage constituted the forage in all diets. Treatments were balanced for parity, body weight, and previous lactation milk production or genetic potential (primiparous cows). Cows were housed in a tie-stall barn beginning 4 weeks prepartum, fed similar diets, and assigned to treatment on the day of calving. Diets were formulated to provide 3.3, 4.8 and 6.5% fat. Diets actually measured 2.1, 3.8, and 5.3% fat. Serum urea nitrogen and cholesterol increased with increased dry matter intake and with increasing dietary fat. Serum triglycerides decreased at parturition and were similar among diets through 20 days postpartum. Thereafter, cows fed the 2.1% fat diet had fewer serum triglycerides than cows receiving 3.8% and 5.3% fat diets. Similar differences were observed with regard to mammary uptake of triglycerides. Serum glucose peaked at calving in all cows and tended to be similar among diets. Glucose uptake by the mammary gland increased with milk production. Cows fed the 5.3% fat diet had less urine ketones by 3 weeks postpartum. Weeks to positive energy balance were 8, 7, and 5 for cows fed 2.1, 3.8, and 5.3% fat diets, respectively. Dry matter intake in kg/day and as a percentage of body weight tended to be greater in the high fat group after 3 weeks of lactation. Milk yield (total and 3.5% FCM) was similar among diets through 10 weeks of lactation. Thereafter, lactation curves in cows fed the 5.3% fat diet were more persistent. Similar trends were observed for milk fat and protein. Milk protein percentage was slightly depressed on the 5.3% fat diet, but protein yield increased.; Dairy Day, 1995, Kansas State University, Manhattan, KS, 1995;

Keywords

Dairy Day, 1995; Kansas Agricultural Experiment Station contribution; no. 96-106-S; Report of progress (Kansas Agricultural Experiment Station and Cooperative Extension Service); 742; Cows; High-fat diets; Milk; Cholesterol

INCLUSION OF FAT IN DIETS FOR EARLY LACTATING HOLSTEIN COWS

J. E. Shirley and M. E. Scheffel

Summary

Twenty-four Holstein cows were used to study the effect of dietary fat on milk production and metabolic traits. Whole cottonseed and tallow were used as fat sources and substituted into the control diet on an isocaloric basis. Chopped alfalfa hay and grain sorghum silage constituted the forage in all diets. Treatments were balanced for parity, body weight, and previous lactation milk production or genetic potential (primiparous cows). Cows were housed in a tie-stall barn beginning 4 weeks prepartum, fed similar diets, and assigned to treatment on the day of calving. Diets were formulated to provide 3.3, 4.8 and 6.5% fat. Diets actually measured 2.1, 3.8, and 5.3% fat. Serum urea nitrogen and cholesterol increased with increased dry matter intake and with increasing dietary fat. Serum triglycerides decreased at parturition and were similar among diets through 20 days postpartum. Thereafter, cows fed the 2.1% fat diet had fewer serum triglycerides than cows receiving 3.8% and 5.3% fat diets. Similar differences were observed with regard to mammary uptake of triglycerides. Serum glucose peaked at calving in all cows and tended to be similar among diets. Glucose uptake by the mammary gland increased with milk production. Cows fed the 5.3% fat diet had less urine ketones by 3 weeks postpartum. Weeks to positive energy balance were 8, 7, and 5 for cows fed 2.1, 3.8, and 5.3% fat diets, respectively. Dry matter intake in kg/day and as a percentage of body weight tended to be greater in the high fat group after 3 weeks of lactation. Milk yield (total and 3.5% FCM) was similar among diets through 10 weeks of lactation. Thereafter, lactation curves in cows fed the 5.3% fat diet were more persistent. Similar trends were observed for milk fat and protein. Milk protein percentage was slightly depressed on the 5.3% fat diet, but protein yield increased.

(Key Words: Cows, High-Fat Diets, Milk, Cholesterol.)

Introduction

Use of fat sources such as whole cottonseed, roasted soybeans, tallow, or rumen-protected fats to increase the energy density of diets for high-producing dairy cows is a general practice in today's dairy industry. Questions concerning the amount to include, when to include it, and the source or sources to use have not been fully answered. Furthermore, questions relating to the metabolic effects of increasing amounts of dietary fat remain unanswered.

Previous studies showed a 14% increase in milk production when tallow was added to the diet at 25 days in milk (KAES Report of Progress 608:19) and 6.8% when added to the diet at 90 days in milk (KAES Report of Progress 716:24). Tallow inclusion in both studies was sufficient to increase total dietary fat to approximately 5%. Field observations suggest that the combined use of whole cottonseed and tallow in total mixed rations permits the feeding of dietary fat in excess of 5% without resorting to the use of rumen-protected fat to prevent depressed feed intake and milk protein percentage.

Use of supplemental fat in the diet of cows during the first 30 to 60 days postpartum is thought to be counterproductive, because the cow is rapidly mobilizing body fat at this time. Increased dietary fat in the early postpartum period might aggravate the normal fatty liver condition, or at best, not be utilized efficiently. Furthermore, high fat diets might result in depressed intake and contribute to increased clinical ketosis. Conversely, if dry matter intake is not depressed and the additional dietary fat is shunted directly to the mammary gland without interfering with liver function, then the cow would return to positive energy balance sooner, resulting in higher peak milk yield and a more persistent lactation curve. The purpose of this study was to investigate the impact of increased dietary fat during the immediate postpartum period on production and metabolic traits of Holstein cows.

Procedures

Diets were control grain mix (diet C; 2.1% fat); control plus 6 lb of whole cottonseed (diet D; 3.8% fat); and control plus 6 lb of whole cottonseed with 1 lb of tallow (diet E; 5.3%). Whole cottonseed and tallow were substituted into the control diet on an isocaloric and isonitrogenous basis. The forage component of all diets included chopped alfalfa hay and grain sorghum silage. Diets were fed twice daily as a total mixed ration (TMR) (50% in the A.M. and 50% in the P.M.) and daily weight backs obtained prior to the A.M. feeding. The 24 cows were housed in a tie-stall barn beginning 4 weeks before calving, fed similar diets, and assigned to treatments on the day of calving. Treatments were balanced for parity, body weight, and previous lactation milk production or genetic potential in the case of first-lactation cows.

Beginning 4 weeks before calving, weekly body weights and condition scores were obtained on the same day of the week and at the same time of the day (± 30 min). Additional weights and condition scores were obtained within 24 hr after parturition. Milk weights were recorded daily. A.M. and P.M. samples were collected weekly and pooled for composition analysis. Milk fat, protein, lactose, solids-not-fat, and somatic cells were determined by the DHI Laboratory, Manhattan, KS.

Urine samples were checked for concentration of ketones on days 5 and 1 prepartum, at calving, and daily for the first 21 days postpartum. Blood samples were obtained from tail and subcutaneous abdominal veins. Serum was analyzed for urea nitrogen, triglycerides, glucose, cholesterol, and bovine somatotropin (bST). Blood samples were collected between 2 and 3 hr after the A.M. feeding. Sampling dates were days 5 and 1 before calving and days 1, 3, 5, 7, 9, 12, 15, 20, 25, 30, 45, 60, 90, 120, and 180 postpartum.

Individual feed ingredients were sampled weekly and composited monthly for analyses. Total mixed rations and weigh backs were sampled weekly for dry matter determination. Feed analyses included dry matter, crude protein, crude fat, crude fiber, ADF, NDF, NE_L, calcium, phosphorus, potassium, chloride, and sulphur.

Cows were observed daily and observations recorded relative to health problems, with particular emphasis on milk fever, ketosis, displaced abomasum, mastitis, feet and legs, off-feed, reproductive abnormalities, and other occurrences that would impact the interpretation of data. Outside daily ambient temperature, humidity, and barn temperature were recorded.

Results and Discussion

The experimental diets (Tables 1 and 2) were formulated to be isocaloric and isonitrogenous. The major difference between diets was the source of calories (i.e., fat substituted for carbohydrates). This substitution created some differences in dietary specifications (Table 3), particularly in nonstructural carbohydrates (NSC), calcium, and neutral detergent fiber (NDF). Increasing the amount of fat increases the energy density of the diet and reduces the amount of dry matter cows must consume to meet their nutrient requirements for a specified level of milk production. This can be particularly important to the fresh cow, because her dry matter intake (Figure 1) is relatively low. Thus, one of the objectives of substituting fat for carbohydrates in diets for lactating cows is to increase nutrient intake as rapidly as possible and reduce the duration of negative energy balance. Results of this study show that weeks to reach positive energy balance after parturition were 8, 7, and 5 for cows fed low-, medium-, and high-fat diets, respectively (Figure 2). These results were achieved from both the higher nutrient density of the diet and the fact that appetite (Figure 1) was not depressed with increasing amounts of supplemental dietary fat. However, the reduction in weeks to reach positive energy balance did not translate into increased production at peak lactation or increase in body condition score (Figures 3 and 4, respectively). Milk production was similar among diets through 10 weeks of lactation. Thereafter, cows fed the high-fat diet were more persistent than cows fed the medium- or low-fat diets. Thus, the practice of adding fat immediately after calving may be convenient in herds with only one group of cows, but it may be economically advantageous to wait until 30 to 60 days postpartum in cases where herd size permits grouping (Table 4).

Body weight and condition scores were similar throughout the study. Cows fed the high-fat diet began the study with an average body score of 2.68 versus 3.02 and 3.08 for cows fed the medium- and low-fat diets, respectively. Consequently, cows fed the high fat diet lost .64 units of body condition, whereas cows receiving the medium- and low-fat diets lost .83 and .84 units, respectively. The difference in initial body condition is probably the reason for the elevated feed intake by the high-fat group. Dry matter intake in lb/day and as a percentage of body weight tended to be higher in the high-fat group after 3 weeks postpartum.

The addition of ruminally unprotected fat to diets in amounts sufficient to increase total dietary fat above 5% may result in a depression in percentage milk protein. We observed a nonsignificant decrease in milk protein percentage, but protein yield (lb/day) tended to follow milk production (Figure 5). The combination of fat sources used in this study, whole cottonseed and tallow, may have an advantage over other sources when fed in a TMR. The whole cottonseed tends to associate with the forage fraction. It is consumed over an extended period and provides a slow release of fat in the rumen, because it becomes a part of the ruminal fibrous layer. Tallow is a saturated fat that requires essentially no energy expenditure by rumen microorganisms during its passage through the digestive system. In essence, the combination of whole cottonseed and tallow might mimic ruminally inert fat sufficient to have no negative impact on rumen microbial activity. Evidence contrary to this conclusion is the concentrations of blood urea nitrogen (BUN). Cows fed the high-fat diet had elevated BUN relative to the other groups. Concentrations of BUN in the high-fat group may have resulted from the low nonstructural carbohydrate (NSC) content of the diet (33.3% vs. 39.8 and 35.7, low- and medium-fat diets, respectively). Earlier studies (KAES Report of Progress 716:24) demonstrated that increasing the dietary NSC in diets containing tallow tended to reduce BUN. The generally recommended level of NSC diets for lactation cows is 35 to 40%.

Supplementing diets for cows in early lactation may reduce the incidence of ketosis. Urine ketone data, expressed as a percentage of cow days exhibiting levels in the moderate or greater range, indicated that cows fed the high-fat diet had less subclinical ketosis by 3 weeks than the other groups. Further studies using more cows and quantitative blood ketone levels are needed to verify this concept.

It has been reported that supplemental dietary fat might reduce the effects of heat stress on milk production. Our data, although inconclusive, show that milk yield from cows receiving the low-fat diet exhibited a sharp drop during weeks 13 and 16 following 3 days of 90 degrees F temperature each time. No response to elevated temperature was noted in the high-fat group.

Serum cholesterol and triglycerides were increased ($P<.01$) by supplemental dietary fat, as expected. No differences were observed in serum glucose and bST concentrations among treatments.

In conclusion, whole cottonseed and tallow can be used safely to increase the energy density of diets for cows during early lactation. However, such diets will notimprove peak lactation performance but will improve persistency of lactation. When herd size is sufficient to permit grouping cows according to stage of lactation, it may be economically advantageous to initiate supplemental fat feeding at 50 to 60 days in milk. Further work is needed to ascertain the ability of dietary fat to reduce heat stress and the incidence of ketosis in high-producing cows.

Table 1. Experimental Diets

Ingredients	Diet C (2.1% fat)	Diet D (3.8% fat)	Diet E (5.3% fat)
	------------------ as fed lb/day	---------------------	
Alfalfa hay	18.0	18.0	18.0
Corn silage	24.0	24.0	24.0
Wheat	2.0	2.0	2.0
Molasses	.9	.9	.9
Whole cottonseed	—	6.0	6.0
Grain mix C	37.5		
Grain mix D		30.5	
Grain mix E			28.5

Table 2. Experimental Grain Mixes

Ingredient	Grain Mix C	Grain Mix D	Grain Mix E
	----------------------------- % fed	------------------------------	
Soybean meal	25.15	26.18	31.0256
Distillers grains	6.22	6.48	7.67
Shelled corn	51.21	48.69	40.67
Soy hulls	12.52	11.91	10.0
Fat	—	—	3.53
Dical	1.31	1.41	1.62
Ground limestone	1.15	2.94	3.14
Bicarb	1.522	1.50	1.41
Mag. oxide	.16	.098	.14
Trace mineral salt	.53	.524	.495
Vitamin premix (ADE)	.187	.227	.245
Vitamin E	.0205	.025	.0275
Selenium	.0205	.025	.0272
Total	100.00	100.00	100.00

Table 3. Ration Specifications for a 1400 Pound Cow Producing 90 Pounds of 4.0% Butter Fat, 3.2% Protein Milk

Item	Diet C (2.1% fat)	Diet D (3.8% fat)	Diet E (5.3% fat)
Est. dry matter (DM) intake, lb/day	59.7	58.6	56.7
Est. DM intake, % BW	4.3	4.2	4.1
Neutral detergent fiber, % DM	31.1	33.4	33.5
Acid detergent fiber, % DM	20.1	22.3	22.4
Protein, % DM	18.1	18.4	19.0
Undigested intake protein, % protein	36.8	36.2	35.8
NE_L, mcal/lb	.77	.78	.81
Calcium, % DM	.78	1.05	1.08
Phosphorus, % DM	.49	.50	.51
Potassium, % DM	1.41	1.44	1.47
Magnesium, % DM	.24	.25	.26
Fat, % DM	3.32	4.84	6.51
Nonstructural carbohydrate, % DM	39.8	35.7	33.3

Table 4. Effects of Dietary Fat on Various Production Traits in Lactating Holsteins

Item	Diet C (2.1% fat)	Diet D (3.8% fat)	Diet E (5.3% fat)	SE
Milk, kg/day	33.4	34.8	35.5	1.88
Milk fat, %	3.52	3.44	3.54	.08
Milk protein, %	3.16	3.00	3.07	.07
Energy corrected milk, kg/day	23.3	23.8	24.8	1.34
Dry matter intake, kg/day	21.4	22.5	23.0	.8
Milk, kg/day				
Weeks 1 to 9	36.6	37.2	37.2	2.36
Weeks 10 to 24	31.4	33.2	34.5	1.67
Milk protein, %				
Weeks 1 to 9	3.15	3.04	3.14	.06
Weeks 10 to 24	3.1	3.0	3.0	.08
Somatic cells ($\times 10^3$)	132	84	85	35

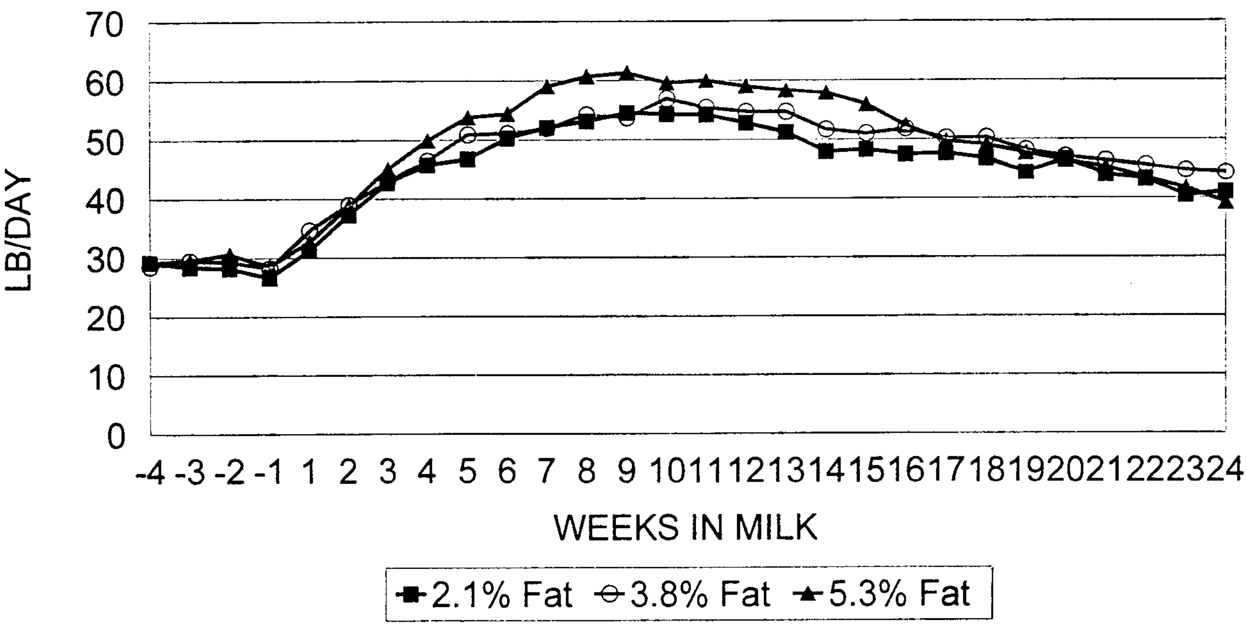

Figure 1. Dry matter intake of cows fed three levels of fat.

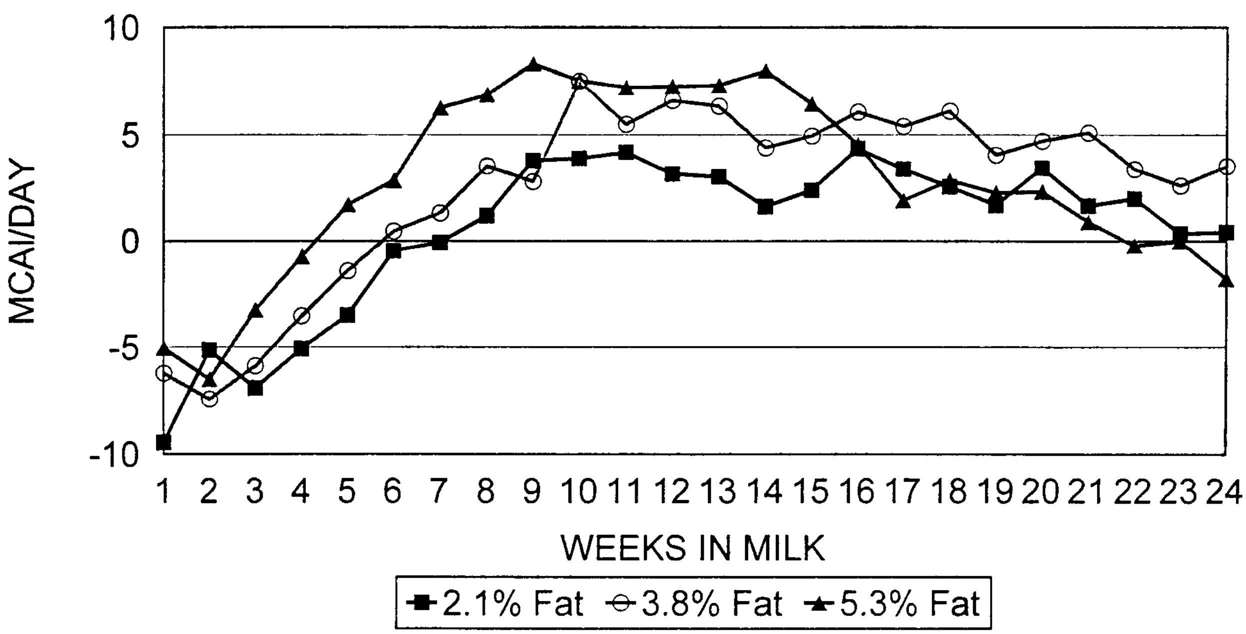

Figure 2. Energy balance of cows fed three levels of fat.

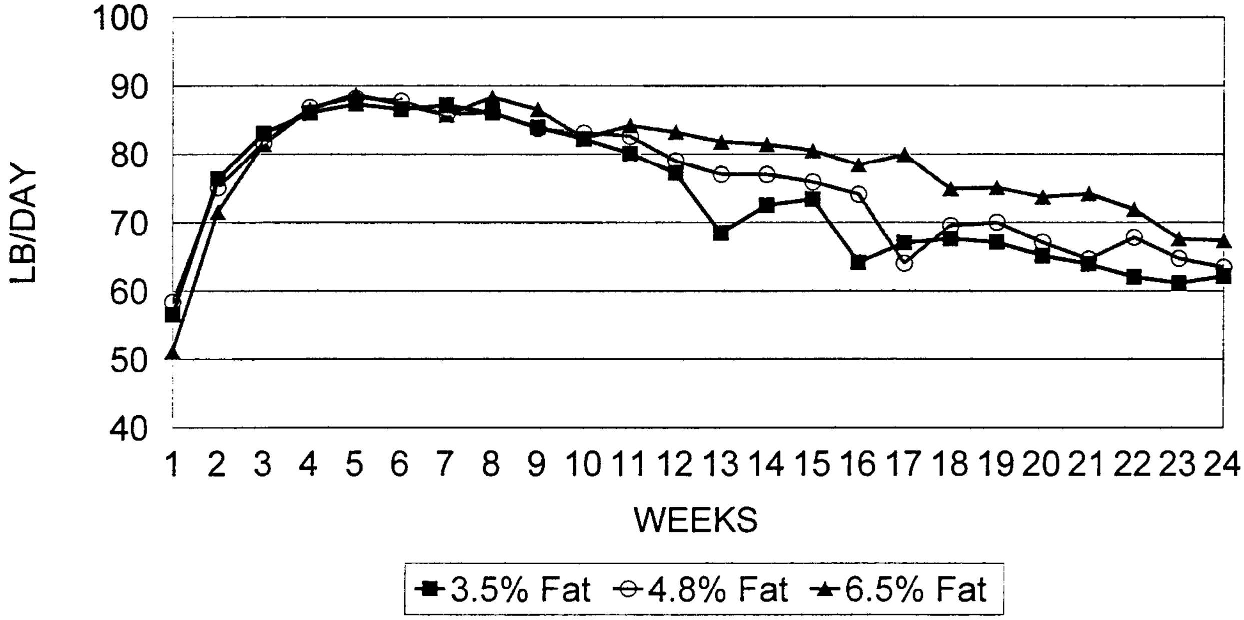

Figure 3. Milk production of cows fed three levels of fat.

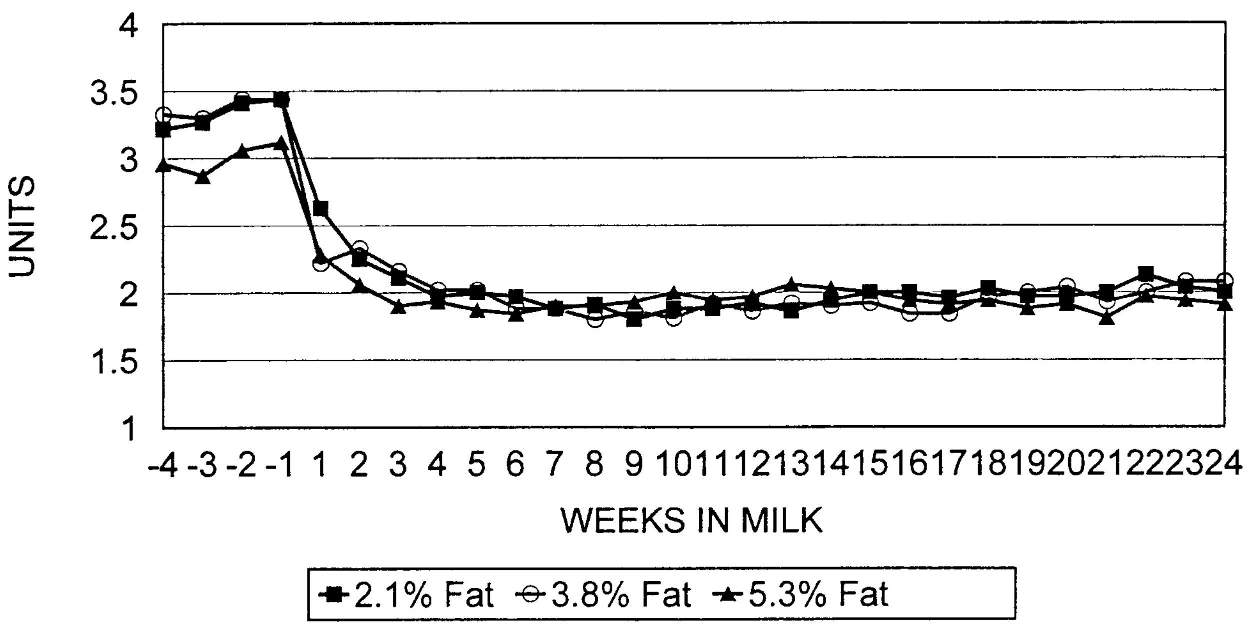

Figure 4. Body condition scores of cows fed three levels of fat.

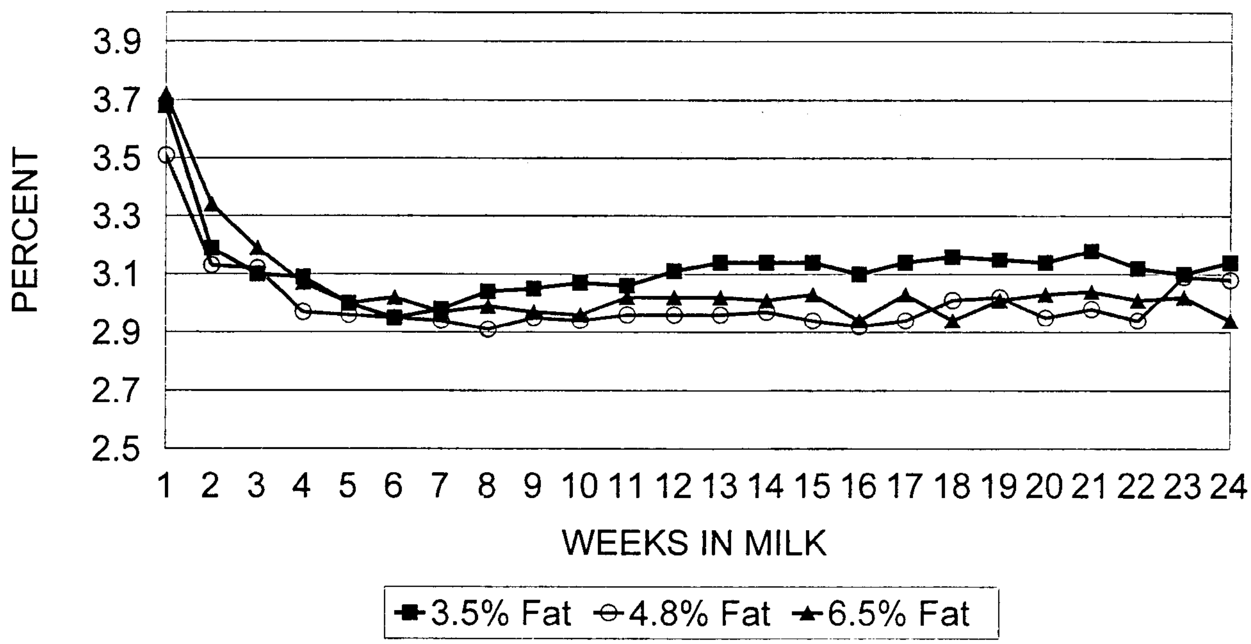

Figure 5. Milk protein for cows fed three levels of fat.