Dairy Foods

Lipase Activity and Milk Production As Related to Sudden Decreases in The Energy of The Cow's Ration

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Story in Brief

Just as "one bad apple can spoil the barrel," it has long been known that "off-flavored" milk from a few animals can spoil an entire tank-load. As the dairy herds in Oklahoma become larger, more and more milk is "pooled" in farm tanks, waiting pick-up by the Co-op truck. As these amounts of milk on the farm become larger, it is even more important to learn the reasons why some cows produce undesirable flavors in their milk on certain days. Then steps can be taken to avoid these flavors and especially to avoid mixing the "off-flavored" milk with the "good" milk already in the tank. In previous work at O.S.U., it was found that rancid flavors were more likely to occur in milk when the cow was in heat. The present study shows that sudden changes in the amount of energy in the cow's ration can be another cause of undesirable milk flavors.

Introduction and Literature Review

Dairy farms now use large refrigerated storage tanks and pool several milkings before shipment to the processor. If an undesirable flavor develops in any part of this milk, the entire tank may develop the defect and then be unsaleable. Dairymen often group their herds according to milk production; the higher producing cows being on a higher plane of nutrition than the lower producing ones, in order to provide them with the energy needed for high milk production. As the cow's stage of lactation progresses, production drops. Then when "fresh" (high producing) cows are added to the higher producing group, some of the cows in later lactation are moved out to make room for the new ones. This change often happens quite abruptly. Simply by opening a gate between two pens, the cows are moved into the new "lower producing" group where the cow is forced to adjust to new feeds and sudden decreases in her level of energy intake. As herds become larger, it is of even greater importance to find the reasons why some cows develop undesirable flavors at certain times. Kelly (7) reported that lipase (an enzyme which is one of the causes for rancid flavors) changed during the estrous cycle. Later work at O.S.U. confirmed this in more detail (14). The present study was designed to measure the effects of sudden changes in the cow's feed intake.

There have been volumes of literature published concerning milk flavors. Probably the best description of these can be found in the book by Nelson and Trout (10). Factors affecting the lipase activity of milk have recently been reviewed by Shahani *et al.* (12), and by True (13). Likewise, volumes of research have been published about feeding dairy cows and this is summarized in many recent textbooks on the subject. Cannon and Rollins (4) also have reviewed the subject, as has Borges (3).

Jensen, *et al.* (6), studied the effects of different rations on lipase activity, but did not evaluate the effects of ration changes. Satter and Bringe (11), in 1970, reported changes in blood metabolites during abrupt ration changes, however, they did not relate this data to lipase activity in milk. Askew, *et al.* (1) reported differences in the lipase activity of biopsy samples from mammary glands of cows which had been abruptly shifted from normal to high-energy rations. These latter two references were the only ones found in which the affects of sudden ration changes were studied. Neither of these involved the effects of the change on lipase activity in milk.

Experimental Methods

Cows, known to be free of disease and other abnormalities, were selected from the O.S.U. dairy herd for these experiments. The animals were assigned individual stalls where they could be fed and handled under controlled, uniform conditions. Body weights of the cows were determined prior to each experiment by weighing the animals before milking for two consecutive days (4 milkings). These weights are then used in calculating the NRC energy requirements of the animal (9). Daily rations consisted of various ratios of alfalfa hay to concentrate. The hay was selected from a single lot which contained 11% digestible protein and 49 megacalories per hundredweight. The concentrate had a "guaranteed analysis" of 11 percent digestable protein and 86 magacalories per hundred weight. Water was available at all times and salt blocks were available in the adjacent exercise lots.

During experimental periods, the cows were milked twice daily. Milk weights were recorded and samples obtained at the evening milking. The samples were immediately cooled to 5°C and stored at that temperature until analyzed. The whole milk was analyzed for the fat and total solids by the Mojonnier method, and solids-not-fat were determined by difference. A portion of each sample was skimmed and analyzed for lipase activity using the method of True (13). Ash and calcium contents of this skimmilk were determined by the method of Jenness (5). Another portion of the skimmilk was dialyzed and its lipase activity, ash, and calcium content were again determined. The statistical analysis system (SAS) was used to analyze the data (2). Linear, quadratic, cubic, and quartic affects of each variable vs. sampling time were determined. Correlation coefficients between time and each variable also were calculated.

This research was divided into three parts: uniformity, preliminary, and experimental trials. During the uniformity trial, samples from one animal were used to standardize laboratory techniques and relate certain measurements to lipase activity. In the preliminary trial, temperature, wind direction, and wind velocity were recorded. These variables were correlated with the lipase activity of the milk from a single animal. The possible affects of stress on the cow from changing day to day conditions also were studied. For example, she was forced into the milking parlor at unusual times during the day. At other times she was "held back" while other cows bypassed her to be fed and milked, while she "fretted". The affects of strenous exercise, involving running the animal immediately before milking until her respiration rate and heartbeat had doubled, also were observed.

In the experimental trial, a "switch back" design (8) was used. Twelve animals were selected for this experiment: eight Ayrshires, two Holsteins, and two Jerseys. These were chosen so that six pairs of animals, based on breed, stage of lactation, and initial milk production were obtained. The pairs were divided into two groups, with one member of each pair assigned at random to each group. A two week standardization period was used to adjust the animals to their new housing and experimental feeding procedures. The treatment consisted of reducing the concentrate intake so that only 80 percent of the NRC energy requirements were being met for one group (low), while the other group was on full feed (normal), and received 100 percent of their NRC energy requirements. The experiment continued for 18 days, which was divided into three 6-day periods, with the treatments as shown in Figure 1. During the experiment, two cows developed mastitis and their data could not be included in the results. One cow had a reoccurrence of a previous

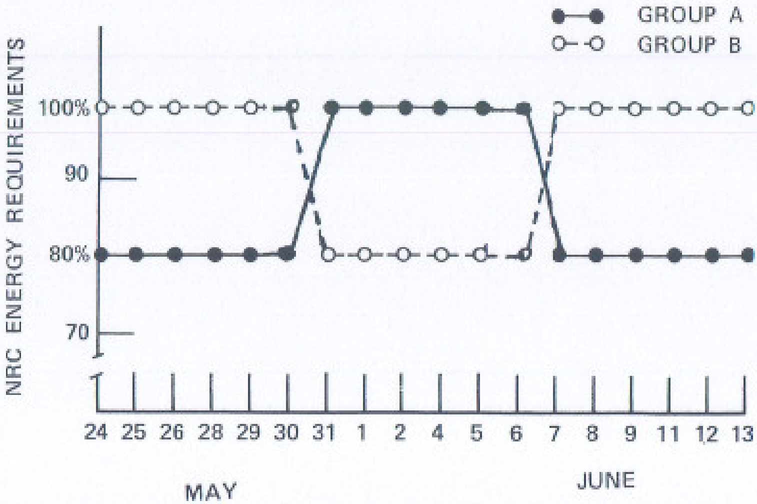

Figure 1. The double reversal design showing the % NRC requirements received by each group of cows, plotted over days.

electrolight imbalance, and also had to be removed from the experiment. The remaining nine cows appeared to be normal and were observed throughout the experimental period.

Results and Discussion

Uniformity Trial

Regression coefficients, sequential sums of squares, and error mean squares calculated from the data in this trial, are shown in Table 1. Large day-to-day variations were noted in the data. In addition, for the relative sizes of the sums of squares for the quartic relationship compared to the linear, quadratic and cubic effects, indicated a cycle variation of the variables from day to day. This cyclic variation was more complicated than could be described by a simple quartic relation, but the data was insufficient to attempt any further model.

Preliminary Trial

Correlation coefficients obtained from the data collected on weather, when compared to lipase activity, showed that the lipase activity of milk

Table 1. Regression coefficients and sequential sums of squares for ten dependent variables on time during twelve day uniformity trial.

Variable	Linear	Quadratic	Cubic	Quartic	EMS[1]
Lipase Units[2]	0.21[3]	0.04	0.12	0.18	0.55
in Skimmilk	—0.96[4]	0.27	—0.03	0.00	
Lipase Units[5]	0.16	0.04	0.16	0.47	0.27
in Dialysate	—0.82	0.30	—0.04	0.00	
Kg Daily Milk	304.30	34.77	34.50	0.32	94.44
Production	0.64	—0.35	0.01	0.00	
mg Ash per	7050.00	5682.00	140.80	8848.00	2355.20
ml Whole Milk	128.00	—44.38	5.24	—0.21	
mg Ash per	1132.00[6]	55.05	1210.00[6]	548.50	142.85
ml Dialysate	—58.55	15.38	—1.63	0.05	
mg Calcium per	2.02	41.69	14.78	191.50	50.90
ml Whole Milk	26.79	—7.77	0.86	—0.03	
mg Calcium per	106.50	79.39	135.50	468.80	92.27
ml Dialysate	—25.70	9.49	—1.22	0.05	
% Fat in	1.12	2.64	0.64	4.80	0.83
Whole Milk	6.62	—1.94	0.22	—0.01	
% Total Solids	0.82	3.88	0.09	1.21	1.69
in Whole Milk	—3.53	1.04	—0.11	00.00	
% Solids-not-fat	5.89	0.76	4.92	6.68	0.64
in Whole Milk	11.99	—3.24	0.35	—0.01	

[1] Error Mean Square.
[2] μ moles of butyric acid liberated per minute per ml of skimmilk at 37°C.
[3] The top line is the sequential sum of squares.
[4] The bottom line is the regression coefficient.
[5] μ moles of butyric acid liberated per minute per ml of dialyzed skimmilk at 37°C.
[6] $P<0.05$.

varied independently of weather (Table 2). In addition, the effects of any stress caused by upsetting the cow's routine in this experiment were not observed to cause any variations in the lipase content of the milk. Milk collected from the animal during the time she was fed the low energy ration had an objectionable odor and taste. This same odor again was apparent in the milk when the cow was abruptly changed from the low ration back to the normal ration. However, by the time the cow had eaten the normal ration for 2-3 days, this odor had disappeared.

Experimental Trial

Statistical analysis of data for this experiment (Table 3), showed that milk production was significantly lower ($P<0.01$) when the cows were on the low ration. Lipase activity also was significantly lower ($P<0.05$) during these periods.

This study is continuing. A trial involving human judges to identify

Table 2. Correlation between lipase activity and three weather variables for 32 observations.

Weather Variable	Correlation Coefficients
Mean Daily Temperature	0.08[1]
Mean Wind Direction	—0.29[1]
Mean Wind Velocity	—0.31[1]

[1] P>0.05.

Table 3. Analyses of variance of milk production, and lipase activity for experimental trial.

Source	df	SS	MS	F
	Milk Production			
Treatment Group	1	77.85	77.85	26.57[1]
Error	7	20.48	2.93	
	Lipase Activity			
Treatment Group	1	0.08	0.08	8.00[2]
Error	7	0.07	0.01	

[1] P<0.01.
[2] P<0.05.

the undesirable flavors caused by feeding changes has been completed and the data is presently being analyzed.

Literature Cited

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