MILK FAT CONTENT AND PRODUCTION PERFORMANCE OF HOLSTEIN DAIRY COWS FED FISH MEAL

L. B. Bruce[1] and M. L. Herlugson

Agricultural and Forestry Experiment Station, Palmer Research Center,
University of Alaska, 533 E. Fireweed, Palmer,
Alaska 99645, USA

Summary

Performance and production of twenty lactating Holstein cows fed diets containing either soybean meal or fish meal as the primary protein source were compared in a continuous or split feeding scheme. At 1 wk prepartum four groups of five animals were placed on each experimental diet. Animals assigned to the continuous feeding scheme were continued on these diets for 10 wk postpartum. At 4 wk postpartum, the diets for the groups assigned to switching protein sources were changed. These treatments were continued for another 6 wk. Milk production and dietary intakes were recorded daily. Milk constituents were measured every 2 d. Cows weights, rumen fluid samples and jugular blood samples were collected weekly. Data showed no effect of early lactation diet on cow performance or milk characteristics. Overall, compared to the soybean meal diet, the fish meal diet lowered the milk fat percent and increased production of milk per unit of dry matter ingested. No differences were observed for volatile fatty acid content of rumen fluid, blood mineral content, milk protein, somatic cell count, 4%-fat corrected milk, dry matter intake, or body weight.
(**Key Words**: Fish Meal, Milk Fat Depression, Milk Production)

Introduction

Interest has been generated in using fish meal as a feedstuff because fish meal has shown rumen-escape protein qualities (Zerbini et al., 1988) and approximately one-third of the fish produced in the world is unusable for human consumption (Barlow and Windsor, 1984). Steers gained faster and more efficiently on a diet containing fish meal (Thonney and Hogue, 1986; Veira et al., 1988) and increased skeletal muscle growth has been reported in lambs fed fish meal compared to non-fish meal diets (Beerman et al., 1986). Some of these effects may be due to rumen-escape protein. Fish meal was slightly lower than soybean meal in amino acid availability (Jorgensen et al., 1984) but has been reported to increase crude protein (CP) digestibility (Randall, 1974). Milk fat content has been consistently decreased when fish meals are fed in dairy diets (Zerbini et al., 1988; Teeter et al., 1989; Blauwiekel et al., 1989; Spain, et al., 1989; and Broderick, 1989). Effects on milk yield have been mixed. Increase in yield has been found in several experiments (Bruce et al., 1989; Broderick, 1989); a number have found no differences (Blauwiekel et al., 1989; Spain et al., 1989). Some report changes in the VFA ratios of acetate to propionate (Hoover et al., 1989) and some find no changes (Zerbini et al., 1988). Pennington and Davis (1975) reported that milk fat depression did not occur when the fish oil was infused into the abomasum. The VFA profiles and milk yields are not consistent, and the mechanism of action is unclear. The milk fat depression that occurs when fish meal is fed is well documented, but the mechanism is not well understood. This study was designed to further evaluate fish meals, specifically salmon meal, as a protein source for lactating dairy cows.

Materials and Methods

Twenty pregnant Holstein cows (average weight 560 kg) were randomly assigned to 1 of 4 groups in a 2 × 2 factorial design. The factors were protein source and feeding scheme. The protein sources were soybean meal, or fish meal. The

[1]Address reprint requests to Dr. L. B. Bruce, Agricultural and Forestry Experiment Station, Palmer Research Center, University of Alaska, 533 E. Fireweed, Palmer, Alaska 99645, USA.
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source of fish meal (Icicle Seafoods, P. O. Box 8, Seward, AK) was salmon by-products, heat dried and ground, containing approximately 65 % CP and 13% fat. The soybean meal was more soluble in rumen fluid than the salmon meal (Husby, 1990). The feeding scheme consisted of either 10 wk of continuously feeding one protein source or switching protein source at 4 wk postpartum. All cows were individually fed. At 1 wk prepartum cows were placed on the experimental diets of 50:50 brome silage and a concentrate (table 1) with either soybean meal (SBM) or fish meal (FM) as the primary protein source. Two groups of five cows each were placed on the SBM diet and two groups on the FM diet. Animals assigned to the continuous feeding scheme were fed for 10-wk. At 4 wk postpartum, the diets for the groups assigned to switching protein sources were changed. These treatments were continued for another 6 wk. Diets were formulated to be iso-caloric and iso-nitrogenous (table 2), however, variability of protein content in salmon meal supply caused small differences in these diets. Concentrates were of a relatively high protein content because the silage was low (8 percent on dry matter basis). Concentrates were blended with the silage in a batch mixer, weighed, and fed ad libitum twice daily; orts were taken daily. Samples of the mixed diet were taken weekly, dried at 50℃ and stored for analyses.

TABLE 1. FEEDSTUFFS USED IN CONCENTRATES FOR EXPERIMENTAL DIETS

	Soybean meal concentrate	Fish meal concentrate
	..... %	
Ingredient		
Corn, ground shelled	9.8	16.0
Barley, ground	48.0	48.0
Alfalfa meal	10.0	10.0
Soybean meal	29.0	–
Fish meal	–	23.2
Molasses	2.0	2.0
Limestone	0.4	–
Trace mineral salt and Vitamin premix[1]	0.8	0.8

[1]Vitamin premix provides per kg of concentrate: vitamin A, 4,400 IU; vitamin D_3, 13,200 IU.

TABLE 2. CHEMICAL COMPOSITION OF THE MIXED DIETS, 50:50 CONCENTRATE: BROME SILAGE

Component analysis	Soybean meal diet	Fish meal diet
Dry matter (%)	43.0	45.8
Percent of dry matter		
Crude protein	23.3	24.9
Ether extract	4.2	5.1
Neutral detergent fiber	49.4	48.3
Acid detergent fiber	26.5	24.1
In vitro dry matter		
Disappearance	65.9	67.2
Ash	7.4	8.0
Calcium	0.5	0.8
Phosphorus	0.3	0.6
Potassium	1.5	1.3
mg per kg dry matter		
Zinc	105	93

Milk production and DM intakes were recorded daily. Milk samples were taken every 2 d and analyzed for milk fat, protein, and SCC (Washington State DHIA Laboratory, 105 South Pine Street, Burlington, Washington). Cows were weighed and rumen fluid, and blood samples were collected weekly from each cow. Rumen fluid samples were collected by esophageal tube, and immediately frozen until time of analyses. Blood samples taken from the jugular vein, were collected in heparinized tubes and refrigerated until analyzed.

Diet samples were ground (1 mm screen) and analyzed for DM (AOAC, 1980), Acid Detergent Fiber (ADF) (Goering and Van Soest, 1970), and ether extract (Randall, 1974; Michaelson et al., 1987). Nitrogen (N) and phosphorus (P) were determined simultaneously by automated continuous flow methodology (Isaac and Johnson, 1976; Michaelson et al., 1987) in an auto-analyzer system (Technicon Industrial Methodology, 1976). In vitro dry matter disappearance (IVDMD) was run with modifications (Tilley and Terry, 1963; Brundage et al., 1981). Diet and blood samples were analyzed for calcium, potassium,

and zinc by atomic absorption spectrophotometry (Perkin Elmer, model 5000, Perkin-Elmer Corporation, Connecticut). Acetate, propionate, isobutyrate, butyrate, isovalerate, and valerate were determined in rumen fluid samples by gas chromatography (Erwin et al., 1961) (Perkin Elmer, model 5320, Perkin-Elmer Corporation, Connecticut). Blood samples were analyzed for blood urea N (Fawcett and Scott, 1960; Searcy et al., 1961).

The ratio of 4%-fat corrected milk produced to DM intake, milk production efficiency (MPE), and the ratio of acetate to propionate in the rumen fluid were calculated. For data collected more frequently than once per week, weekly means were calculated and used for data analysis. All data were analyzed as polynomial regression curve data (Allen, 1983). Calculated and collected parameters were regressed as a polynomial over the 10 wk collection period and equations then statistically analyzed using the GLM procedure of the Statistical Analysis System (1985). This procedure allows comparison of both changes related to time and comparison among treatment groups.

Results and Discussion

Early lactation treatment had no effect upon any of the parameters measured. In each case statistical contrasts indicated no difference between similar 4 wk postpartum diets. Therefore, the like ending groups were pooled and data analyzed for two groups rather than four. Dietary fish meal decreased percent milk fat ($p < .01$; table 3) and was more efficient ($p < .01$) for fat-uncorrected milk production. There were strong period effects ($p < .01$) on DM intake, milk

TABLE 3. DRY MATTER INTAKE (DMI), MILK PRODUCTION (MP), MP / DMI (MPE), MILK FAT PERCENTAGE (MFP%), FOUR PERCENT FAT CORRECTED MILK (4%- FCM), AND 4%-FCM / DMI (4%-MPE) AVERAGES FOR INDIVIDUAL COWS FED AN EXPERIMENTAL DIET WITH EITHER SOYBEAN MEAL (SBM) OR FISH MEAL (FM) BASED CONCENTRATE FOR 4 10 WK OF LACTATION

Treatment	Week of lactation						
	5	6	7	8	9	10	Mean (S.D.)
[1]DMI kg d^{-1}							
SBM	19.9	20.5	21.0	22.6	21.9	21.9	21.3 (1.0)
FM	17.5	18.3	18.8	19.0	19.6	19.7	18.8 (.8)
[1]MP kg d^{-1}							
SBM	31.3	30.6	30.0	29.2	28.7	28.0	29.6 (1.2)
FM	34.0	35.3	33.6	33.8	33.4	32.6	33.8 (.9)
[2]MPE							
SBM	1.59	1.52	1.46	1.31	1.32	1.29	1.42(.13)
FM	2.02	1.93	1.79	1.79	1.71	1.65	1.82(.14)
[2]MFP%							
SBM	2.98	3.04	3.22	3.27	3.09	3.36	3.16(.15)
FM	2.79	2.49	2.39	2.51	2.48	2.50	2.53(.14)
[1]4% FCM kg d^{-1}							
SBM	26.5	26.2	26.5	25.9	24.6	25.2	25.8 (.8)
FM	27.2	26.2	25.0	25.7	25.4	24.8	25.7 (.9)
[1]4%-MPE							
SBM	1.34	1.29	1.29	1.17	1.13	1.15	1.23(.09)
FM	1.64	1.48	1.35	1.38	1.31	1.27	1.41(.14)

[1]The regression curves for fish meal and soybean meal were not different ($p > .10$).
[2]The regression curves for fish meal and soybean meal differed ($p < .01$).

production, 4% FCM, milk protein, MPE, and body weight, that were characteristic of a typical lactation curve. There was a strong period by diet interaction for MPE using fat-uncorrected milk ($p < .01$). None of the other parameters evaluated produced measurable differences between treatment groups. Cow weights were not different due to treatment, although the FM group tended to lose weight ($p < .05$; SBM beginning weight 558 ± 61 kg, ending weight 570 ± 60 kg; FM beginning weight 561 ± 60 kg, ending weight 554 ± 66 kg; FM beginning weight 561 ± 60 kg, ending weigh 554 ± 66 kg). There were some important tendencies that should be discussed. Fish meal tended to increase kg of raw milk produced, to increase MPE using 4% FCM, and decrease dry matter intake, with no change in kg 4% FCM produced (table 4). The fish meal diet was higher in Ca and P (table 2). The estimated nutrient balance for the two dietary treatments showed no differences for Ca and P. Ether extract was higher in the FM concentrate ($p < .04$) than in the SBM concentrate. Dietary N showed a similar pattern. No other differences were noted in feedstuffs. Ruman VFA content, blood minerals and urea-N content did not differ ($p > .05$; table 4) between treatments.

TABLE 4. RUMEN FLUID VOLATILE FATTY ACID AND BLOOD MINERAL CONTENT OF COWS FED RATIONS WITH EITHER SOYBEAN MEAL (SBM) OR FISH MEAL (FM) BASED CONCENTRATE

Parameter	SBM	FM
[1]Rumen fluid		
Acetate (mol 100 mol^{-1})	60.4	59.6
Propionate (mol 100 mol^{-1})	19.3	20.3
Butyrate (mol 100 mol^{-1})	11.1	11.5
iso-Butyrate (mol 100 mol^{-1})	5.9	5.3
Valerate (mol 100 mol^{-1})	1.1	1.1
iso-Valerate (mol 100 mol^{-1})	1.8	1.8
Acetate:Propionate	3.2	3.0
[1]Blood		
Potassium (mg kg^{-1})	374	352
Magnesium (mg kg^{-1})	24.9	23.4
Iron (mg kg^{-1})	216	210
Zinc (mg kg^{-1})	1.6	1.4
Copper (mg kg^{-1})	63.3	64.6
Urea Nitrogen (mg dL^{-1})	26.0	26.4

[1]treatments did not differ, $P > .05$.

These data do not reveal any evidence as to the mechanism by which milk fat decreased with the addition of fish meal to the diet, or why fish meal was more efficient in milk production. Both of these effects are potentially beneficial to the dairy industry and need further research. This is especially true in areas, such as Alaska, where curently no premium is paid for milk fat content.

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