Effect of Supplemental Fish Meal on Milk Yield and Milk Composition of Holstein Cows during Early Lactation

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ABSTRACT : Data of 15 multiparous Holstein cows kept at Ibaraki Prefectural Animal Experiment Station were collected from 10 weeks prepartum to 20 weeks postpartum. Cows were assigned randomly to a soybean meal (SBM) diet or a fish meal (FM) diet from 4 weeks before expected calving date to 20 weeks postpartum. Each diet was formulated to contain similar amounts of CP, ADF, and NDF. In the FM diet, 2.5 and 5% of fish meal were supplemented as total mixed rations in prepartum and postpartum periods, respectively. Compared to the SBM diet, undegraded intake protein (UIP) and Met were higher in the FM diet, but Lys was low. Body weight and dry matter intake were not affected by supplemental FM, and dry matter intake increased by 6 weeks postpartum and maintained constant after 7 weeks postpartum. Cows in the FM diet remained high milk production during the experimental period, but milk yield in the SBM diet decreased gradually after 6 weeks postpartum. Supplemental FM increased milk yield and protein yield from 10 to 20 weeks postpartum when FM intake was 1.19 kg/d, although milk protein was not improved. There were no significance differences in fat content and fat yield between FM and SBM diets. Supplemental FM had no effect on plasma glucose and urea-N at parturition and 7 weeks postpartum. Thus, the increased milk and protein yield may be due to the combination of carryover effect of supplemental UIP or Met in FM from 4 weeks prepartum to 10 weeks postpartum and direct effect of supplemental FM. *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 3 : 329-333)*

Key Words : Fish Meal, Milk Yield, Protein, Fat

INTRODUCTION

The nutrient requirement of dairy cows increase with milk yield, but high producing cows in early lactation cannot consume sufficient DM to support maximal milk yield. High producing dairy cows require high energy and protein diets during early lactation, because energy and protein are mobilized from body stores to support high milk production (NRC, 1988). The transition period from nonlactation to lactation as well as early lactation period imposes physiological and nutritional stress on the dairy cows, and dry matter intake, milk production and herd health of cows may be impaired (Grant and Albright, 1995).

The source of dietary CP and energy fed to dairy cows influences the utilization of N and energy in the rumen and the flow of nutrients to the small intestine. Microbial synthesis in the rumen is incapable of providing sufficient protein to the high producing cows, and recommendation has been developed for undegraded intake protein (UIP) and high quality of essential amino acid (EAA) profile of bypass protein (NRC, 1988). Because ruminal undegradable protein may increase the total amount of EAA that is delivered to the small intestine and modify their profile (Calsamiglia et al., 1995), adequate supply of protein to the small intestine of lactating dairy cows is essential for maximum milk yield.

Soybean meal (SBM) is a conventional protein supplement for dairy cows, but UIP content is low in SBM. Fish meal (FM) is an excellent protein source for high producing cows, because FM is well balanced in EAA profile and also is rich in CP that is degraded slowly in the rumen (Hussein and Jordan, 1991; Santos et al., 1998). However, dietary FM has been frequently associated with milk fat depression in lactating dairy cows and reduced milk fat content was related to a reduction in the ruminal ratio of acetate to propionate and the high level of polyunsaturated fatty acids in FM (Windschitl, 1991; Spain et al., 1995). Thus, the strategies of supplemental FM are necessary to stimulate increased lactating performance without decreasing milk fat content. Long-term experiments during periparturient and early lactation periods are ideal approach for the evaluation of FM on lactating performance, but few data are available. The objective of this study is to investigate the effect of supplemental FM on dry matter intake, body weight, and milk production of dairy cows from 4 weeks prepartum to 20 weeks postpartum.

MATERIALS AND METHODS

Data of 15 multiparous Holstein cows kept at Ibaraki Prefectural Animal Experiment Station (Tomobe, Japan) were collected from November 1995 to July 1997. Cows were managed in individual tie

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stall and a paddock throughout the experimental period from 10 weeks prepartum to 20 weeks postpartum. According to the parity and pre-milk yield, cows were assigned to a control (SBM) diet or a experimental (FM) diet from 4 weeks before expected calving date to 20 weeks postpartum.

Ingredient and chemical composition in the diets were shown in tables 1 and 2. Chemical composition in the diets, including degradable intake protein (DIP) and EAA, were analyzed by Dairy Related Technical Research Institute (Nishishirakawa, Japan). The contents of DM, OM, CP, ADF, NDF and ether extract were determined according to the methods of AFFRCS (1995). The contents of EAA and UIP were determined by HPLC and the method of Ørskov (1982), respectively.

The diets were formulated to contain similar amounts of CP, ADF, and NDF in prepartum and postpartum period. The FM diets contained 2.49 and 4.98% of FM as a whole meal in prepartum and postpartum periods, respectively, and CP content in FM was 71%. From 10 to 4 weeks prepartum, similar feed were offered to meet 90% of TDN requirements (AFFRCS, 1994) of each cow. From 4 weeks prepartum to parturition, cows were fed to meet 120% of maintenance requirements plus requirements for TDN for the last 2 mo. of gestation (AFFRCS, 1994) as a total mixed ration (TMR). The gestation length was assumed to be 280 d. After parturition, cows were fed as ad libitum intake in TMR. The amounts of feed offered and residuals were measured daily. Body weight of cows were measured each week from 9 weeks prepartum to 20 weeks postpartum.

Cows were milked twice daily, and milk weights were recorded. Milk samples were collected each week from 1 to 20 weeks postpartum and milk analyzed was a composite sample of morning and evening milking. Milk fat and protein contents were analyzed by Milko-Scan automated spectrophotometer (Foss Electoric, Denmark). Blood samples were obtained by jugular puncture into heparinized vacuum tubes at parturition and 7 weeks after parturition. Blood samples were centrifuged immediately after collection, and plasma glucose and urea N were determined using commercial kits (Wako Pure Chemical Industries Ltd., Japan).

Data of body weight, milk yield and milk composition of cows were analyzed by the least squares ANOVA using the general linear models procedure of SAS (1988). The model was as follows;

$$Y_{ijk} = \mu + T_i + C_{(i)j} + W_k + TW_{ik} + TW_{ik} + e_{ijk}$$

where

μ = overall mean,
T_i = effect of treatment
$C_{(ij)k}$ = randomly variable cow nested in treatment,
W_k = effect of sampling time,
TW_{ik} = interaction, and
e_{ijk} = residuals.

Significance was declared at $p<0.05$. An ANOVA was performed, and the differences were tested by least significant difference.

Table 1. Ingredient composition of TMR[1]

	Prepartum		Postpartum	
	SBM diet	FM diet	SBM diet	FM diet
	(%)			
Timothy hay	45.50	45.50	26.00	26.00
Alfalfa hay	24.50	24.50	14.00	14.00
Corn	15.42	15.00	30.84	30.00
Soybean meal	3.69	-	7.38	-
Fish meal	-	2.49	-	4.98
Barley	2.40	2.49	4.80	4.98
Cottonseed	2.25	2.25	4.50	4.50
Soybean full	1.35	1.50	2.70	3.00
Alfalfa pellet	1.89	1.50	3.78	3.00
Beet pulp	0.45	1.50	0.90	3.00
Wheat bran	1.02	1.02	2.04	2.04
Corn gluten feed	1.02	1.02	2.04	2.04
Molasses and mineral	0.51	1.23	1.02	2.46

[1] Vitamins and trace minerals were added in TMR.

Table 2. Chemical composition of TMR[1]

	Prepartum		Postpartum	
	SBM diet	FM diet	SBM diet	FM diet
DM, %	86.81	86.72	87.20	87.01
OM, %	93.10	92.98	94.22	93.98
CP, %	15.02	15.08	16.31	16.44
UIP, %	4.64	5.12	5.60	6.60
ADF, %	27.54	27.49	20.61	20.51
NDF, %	45.64	45.72	36.28	36.40
Ether extract, %	2.66	2.75	3.72	3.90
Essential amino acid, %				
Arg	0.54	0.57	0.67	0.72
His	0.25	0.25	0.28	0.29
Ile	0.86	0.85	0.95	0.93
Leu	1.59	1.59	1.88	1.87
Lys	0.51	0.49	0.55	0.52
Met	0.12	0.13	0.14	0.17
Phe	0.95	0.96	1.04	1.06
Thr	0.60	0.61	0.63	0.67
Val	0.99	1.02	1.06	1.13

[1] All values expressed on a DM basis except for DM.

RESULTS AND DISCUSSION

In the present experiment, no metabolic disorders occurred to the cows during the periparturient and lactation period. Prepartum body weight and dry matter intake of cows were not affected by supplemental FM (table 3), because cows in each diet consumed most of the feed before parturition. Postpartum body weight and dry matter intake of cows were not affected by supplemental FM.

Table 3. Least squares means (±SE) of body weight, milk yield and milk composition of cows

	Diet	
	SBM	FM
Number of cows	7	8
Age, mo	69.6 ± 6.6	63.0 ± 6.2
Gestation length, d	281 ± 3	279 ± 2
Calf birth weight, kg	43.6 ± 2.0	45.1 ± 1.8
Prepartum[1]		
Body weight, kg	634.8 ±16.6	651.1 ±15.5
Dry matter intake, kg/d	8.70 ± 0.12	8.87 ± 0.11
Early lactation[2]		
Body weight, kg	603.2 ±15.0	601.2 ±15.5
Dry matter intake, kg/d	21.7 ± 0.5	22.1 ± 0.4
Milk production		
Milk yield, kg/d	37.0 ± 2.0	38.2 ± 1.9
4% FCM, kg/d	36.6 ± 1.4	37.6 ± 1.3
Fat, %	4.10 ± 0.25	4.08 ± 0.23
Fat yield, kg/d	1.46 ± 0.06	1.50 ± 0.06
Protein, %	3.14 ± 0.10	3.22 ± 0.09
Protein yield, kg/d	1.14 ± 0.04	1.21 ± 0.04
Mid lactation[3]		
Body weight, kg	628.2 ±15.6	637.5 ±14.6
Dry matter intake, kg/d	23.3 ± 0.5	23.9 ± 0.4
Milk production		
Milk yield, kg/d	33.1 ± 1.9[b]	37.8 ± 1.8[a]
4% FCM, kg/d	33.5 ± 1.2	35.1 ± 1.1
Fat, %	4.06 ± 0.23	3.60 ± 0.22
Fat yield, kg/d	1.35 ± 0.05	1.33 ± 0.05
Protein, %	3.14 ± 0.11	3.15 ± 0.10
Protein yield, kg/d	1.04 ± 0.05[d]	1.18 ± 0.05[c]

[a,b] Means within same row with different superscript differ (p<0.10).

[c,d] Means within same row with different superscript differ (p<0.05).

[1] From 9 to 1 week prepartum.

[2] From 1 to 10 weeks postpartum.

[3] From 11 to 20 weeks postpartum.

Cows gained 0.97 and 0.88 kg/d in the FM and SBM diets during prepartum period, respectively, and body weight of cows increased after 3 weeks postpartum in each diet (figure 1). Dry matter intake of cows increased gradually by 6 weeks postpartum and thereafter remained constant (figure 2). Cows in each diet were recovered above the recommendations of TDN and CP (AFFRC, 1994) by 4 and 3 weeks postpartum, respectively.

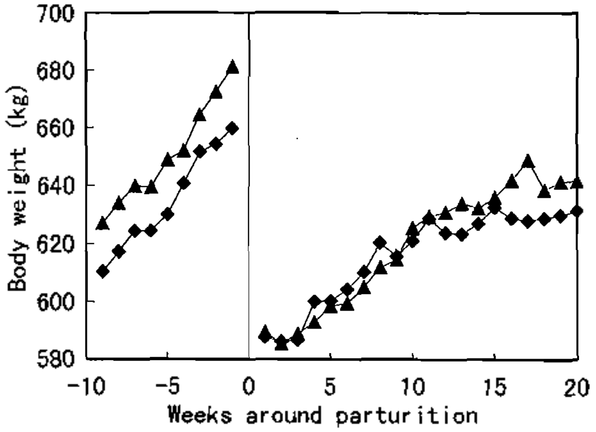

Figure 1. Body weight of cows fed the SBM diet (◆) and FM diet (▲)

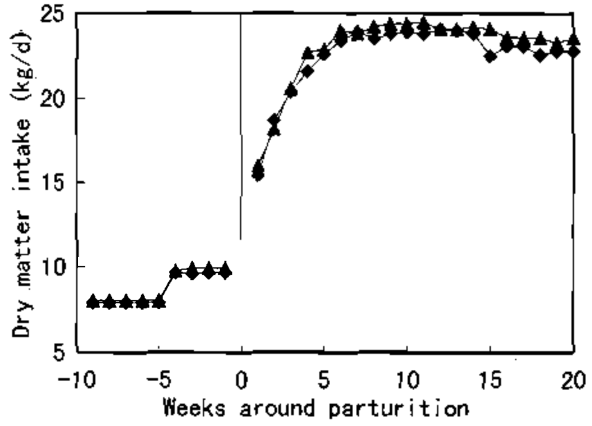

Figure 2. Dry matter intake of cows fed the SBM diet (◆) and FM diet (▲)

Cows in the FM diet remained high milk production during the experimental period, but milk yield in the SBM diet decreased gradually after 6 weeks postpartum (figure 3). Supplemental FM increased milk yield (p<0.10) and protein yield (p<0.05) from 10 to 20 weeks postpartum, although milk protein content was not affected. There were no significance differences in fat content and fat yield between FM and SBM diets. Milk fat and protein decreased by 3 weeks postpartum and thereafter remained almost constant throughout the experimental periods (figures 4 and 5). Supplemental FM had no effect on plasma glucose and urea N at parturition and 7 weeks postpartum (table 4).

Production and composition of milk varies with the uptake of nutrients by the mammary gland, and this is influenced by mammary blood flow and utilization of nutrients by mammary gland (Kume and Tanabe, 1993).

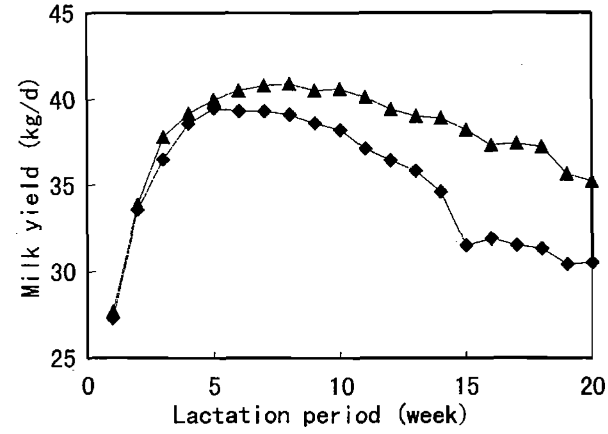

Figure 3. Milk yield of cows fed the SBM diet (◆) and FM diet (▲)

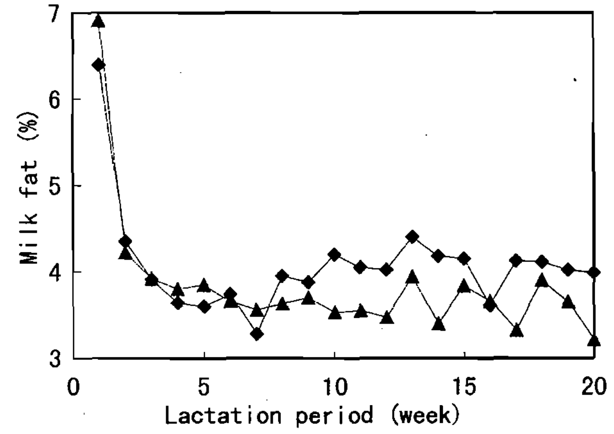

Figure 4. Milk fat of cows fed the SBM diet (◆) and FM diet (▲)

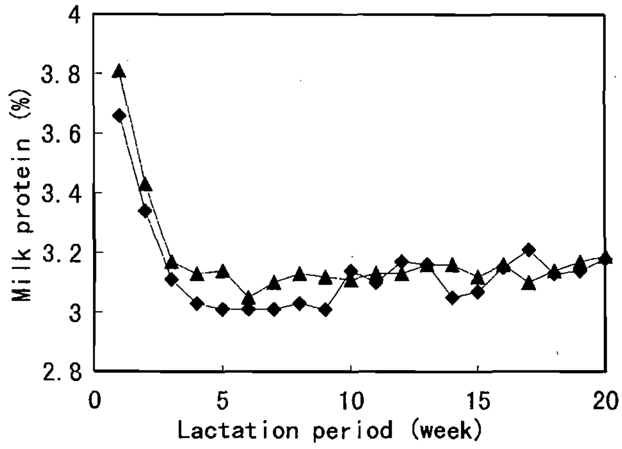

Figure 5. Milk protein of cows fed the SBM diet (◆) and FM diet (▲)

Table 4. Least squares means (±SE) of plasma glucose and urea-N of cows at parturition and 7 weeks postpartum

	Weeks postpartum	Diet	
		SBM	FM
Number of cows		7	8
Glucose, mg/dl	0	76.3±6.4	74.3±6.0
	7	62.3±2.8	61.2±2.6
Urea-N, mg/dl	0	22.0±1.8	23.9±1.7
	7	15.2±1.3	13.6±1.2

Most research suggests that increasing energy intake will increase both content and yield of protein in milk and milk yield is improved by increasing CP intake (DePeters and Cant, 1992). Because energy and CP intakes as well as plasma glucose and urea N were similar in each diet, milk production may be not altered by the energy and CP level in the present study.

The purpose of protein supplement with low ruminal degradability in the diet is not only to reduce protein losses during microbial fermentation in the rumen but also to increase the quantity of protein supplied to the small intestine for absorption and to improve EAA balance of absorbed protein (Akayezu et al., 1997). Supplemental FM provided greater amounts of UIP and EAA, such as Lys and Met, which are considered to be the limiting EAA for milk yield with normal dairy cow feeding practices (Hussein and Jordan, 1991; Santos et al., 1998). Although reports in the literature on the effects of replacing SBM with FM on milk production have not been consistent, supplemental FM of cows fed mainly corn silage increased milk production by a means of 1.6 kg/d (Burke et al., 1997). Santos et al. (1998) reported that >4% of FM in the diet DM accounted for most of the positive effects on milk yield from UIP and a good balance of Lys and Met, and replacement of SBM with FM beneficially affected cows yielding >30 kg/d of milk. In this experiment, supplemental FM improved milk yield and protein yield of cows fed mainly hay from 10 to 20 weeks postpartum, when FM intake was 1.19 kg/d. However, supplemental FM had no effect on milk production for 10 weeks postpartum.

Huyler et al. (1999) reported that concentrations of UIP greater than 3.1% of DM for 6 weeks prepartum did not affect milk yield and composition for 10 weeks postpartum, but supplemental UIP affected protein metabolism. In the present experiment, UIP and Met were higher in the FM diet, and the increased intake of UIP and Met were 273 and 9 g/d in the FM diet from 10 to 20 weeks postpartum. The increased milk and protein yield from 10 to 20 weeks postpartum in this study may be due to the combination of the carryover effect of supplemental UIP or Met in FM from 4 weeks prepartum to 10 weeks postpartum and the direct effect of supplemental FM. However, cows fed the FM tended to have higher milk protein production during early lactation period and higher milk production during the first 6 week postpartum (Carroll et al., 1994), and 21 g/d of rumen-protected Met increased protein contents of milk, even for dairy cows that are in a negative energy balance (Rulquin and Delaby, 1997). Thus, no effect of FM on milk production for 10 weeks postpartum suggested that greater amounts of UIP or EAA are needed for lactating cows during early lactation period.

The greatest changes by diet can be brought in milk fat and far small changes are possible in milk protein (Sutton, 1989). Ruminal fiber digestion may be decreased by the presence of polyunsaturated fatty acids in FM and ruminal escape of polyunsaturated fatty acid may alter postruminal lipid metabolism, which includes decreased uptake of plasma fatty acids by the mammary gland (Spain et al., 1995). The decrease in milk fat content were more common when the amount of FM was from 1 to 2.6 kg/d (Burke et al., 1997). However, FM decreased milk fat, but due to the differences in milk yield, fat yields were similar for cows fed the SBM and FM (Wohlt et al., 1991). In the present study, milk fat content and fat yield were not depressed by 1.19 kg/d of FM, partly because ADF and NDF contents in the FM and SBM diets were similar.

Most metabolic disorders occur at or shortly after parturition and represent a failure of the cow to adjust to the rapid onset and stress of high milk production (NRC, 1988). The decreased feed intake altered energy and protein status of periparturient cows (Toharmat et al., 1998), and plasma urea N remained low through 10 weeks lactation, which is consistent with observed BW losses and it appears that protein reserves were exhausted by 10 weeks (Wohlt et al., 1991). Thus, further study is needed to clarify the effect of supplemental UIP or EAA on milk performance around parturition and early lactation period.

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