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Effects of Pre and Postpartum Feeding Fish Meal on Milk Yield and Metabolic Responses in Early Lactating Dairy Cows

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Abstract: The study was designed to test the effects of pre- and postpartum feeding Fish Meal (FM) on milk yield and composition, dry matter intake and plasma concentrations of metabolites in early lactating cows. From 21 days before predicted calving time to 35 d in Milk (DIM), cows were fed diets containing none (control) or 3.5 and 1.95% fish meal during prepartum and postpartum periods. Diets were formulated to be isoenergetic and provide similar amounts of NEL and NFC using the Cornell Net Carbohydrate and Protein System. Milk yield (36.25, 38.73±3.67 kg d^{-1}) and dry matter intake (18.72, 19.13±0.94 kg d^{-1}) were similar among the diets. Dietary treatments had no significant effect on milk composition or body weight change. Body condition score was also similar between the diets. Dietary treatments had no significant effect on serum concentrations of glucose, cholesterol, triglycerides and serum urea nitrogen during the week preceding and weeks after calving. Serum cholesterol concentrations increased over the time ($p<0.0001$). Results from this experiment demonstrate that dietary supplementation with 3.5 and 1.95% fish meal during prepartum and postpartum periods had no effect on milk production and composition, dry matter intake and blood metabolites.

Key words: Dairy cow, fish meal, production, follicular dynamic, postpartum

INTRODUCTION

The transition phase, typically defined as 3 week before to 3 week after parturition, is viewed as a critical time in the lactation cycle of a dairy cow. During this period, the cow experiences a series of nutritional, physiological and social changes and is more vulnerable to infectious and metabolic diseases (Overton and Waldron, 2004; Huzzey *et al*., 2005). During early lactation Dry Matter Intake (DMI) lags behind the nutrient requirements for milk yield; consequently, lipids, proteins and minerals are mobilized from body stores to support milk synthesis (Heravi Moussavi *et al*., 2007a). Fish Meal (FM) is used in dairy cow ration as a source of RUP (Mattos *et al*., 2002). Greater rumen escape of FM protein is known to increase efficiency of protein utilization in lactating cows. Moreover, FM has an excellent profile of amino acids and is a good source for the 2 most limiting amino acids for milk synthesis, lysine and methionine. Fish meal contains oil (8-10% of DM) including a significant amount of long-chain n-3 polyunsaturated fatty acids, Eicosapentaenoic (EPA) and Docosahexa-enoic Acid (DHA) and represents a source of energy for the early lactating cow. Of the available feedstuffs that are high in undegradable protein, fish meal often is effective in improving milk production. Meanwhile, effects of fish meal on milk production and composition are inconsistent (Santos *et al*., 1998). Although, some reports observed increased milk yield after adding fish meal to diet, some others reported no apparent benefit. On the other hand, reports on the effect of fish meal on blood metabolites in pre- and postpartum cows are rare and need more investigation.

The objective of this study was to compare diets with or without fish meal from transition period up to 35 DIM and their effects on milk production and composition, dry matter intake and blood metabolites in early lactation Holstein cows.

MATERIALS AND METHODS

From approximately 3 weeks before calving to 35 days after calving, ten multiparous Holstein cows were housed in tie stalls. Cows were blocked by parity, expected calving date and previous 305-2X milk production and were randomly assigned within block to 1 of 2 diets containing none (n = 5) or 3.5 and 1.95% Kilka fish meal (Mafan Co, Tehran, Iran) during the prepartum and

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postpartum periods, respectively. Diets were formulated to be isoenergetic and to provide similar amounts of NEL and NFC using the Cornell Net Carbohydrate and Protein System (Fox *et al*., 2004). At parturition, rations were adjusted to supply nutrients required during early lactation. Concentrate mixtures and forage sources were mixed in a weighting and mixing unit and offered in the TMR form twice daily to allow 5-10% orts (as-fed basis). Orts were collected daily and weighted. The TMR were sampled weekly throughout the experiment and DM content was determined by drying at 110°C for 18 h. Samples of TMR were collected weekly, composited monthly and analyzed by wet chemistry procedures for CP, NDF, ADF and ether extract. The weekly TMR samples were stored in -20°C until the analyses. Ingredient and nutrient composition of the diets are listed in Table 1. Cows were milked 3 times per day at 0100, 0930 and 1700 h and yields were recorded. Milk samples were collected from each milking on 1 d per wk and composited for analysis of milk composition (Micro Scan; FOSS Electric A/s, Denmark). Cows were weighed weekly after morning milking (0930 h) and BCS was recorded using a 5-point scale (1 = thin to 5 = fat; Edmonson *et al*., 1989). The Ferdowsi University of Mashhad and Department of Animal Science Animal Care and Use Committees approved all procedures involving experimental cows.

Using vacutainer tubes, blood samples were collected weekly from d -7 to 35 relative to calving via venipuncture of coccygeal vessels before the morning feeding to monitor serum metabolites. Serum was separated immediately after collection by centrifugation (20 min at 1,000×g) and stored at -20°C until analysis for metabolites. Plasma metabolites were analyzed by auto-analyzer Vitalab Selectra (E. Merck Dramstadt, Germany).

Milk yield and composition, DMI, BW, BCS and blood metabolites were analyzed by using a mixed model (PROC MIXED, SAS Inst. Inc., Cary, NC) for a completely randomized design with repeated measures using the following model:

$$Y_{ijk} = \mu + T_i + A_{(i)j} + D_k + (T \times D)_{ik} + \varepsilon_{ijk}$$

Where,

Y_{ijk} = Dependent variable.
μ = Overall mean.
T_i = Treatment effects.
$A_{(i)j}$ = Random effects of animal within treatments.
D_k = Effects of sampling day or time.
$T \times D_{ik}$ = Interaction effects of treatment and sampling day or time.
ε_{ijk} = Residual error associated with the ijk observation.

Overall effect of treatment was tested using cow within treatment as the error term. For all analyses, least squares means were calculated. Means were separated by Tukey- Kramer multiple range test.

Table 1: Ingredient and chemical composition of the experimental diets[1]

	Prepartum		Postpartum	
Variable	Control	3.5% FM	Control	1.95% FM
Ingredient, % of DM				
Corn silage	26.81	26.81	15.64	15.64
Alfalfa hay	17.42	17.42	21.35	21.35
Wheat-straw	6.82	6.82	-	-
Barley grain	10.37	10.37	10.32	10.32
Corn grain	10.37	10.37	10.32	10.32
Molasses	-	-	3.05	3.05
Cottonseed	5.43	5.43	6.13	6.13
Soybean meal	10.34	6.89	14.08	12.14
Beet pulp-shreds	3.48	3.48	3.13	3.13
Beet pulp-dehydrate	-	-	1.78	1.78
Wheat bran	6.39	6.39	10.43	10.43
Fish meal	0	3.45	0	1.94
Oystershell	0.76	0.76	0.60	0.60
Megalac	-	-	1.19	1.19
Bicarbonate sodium	-	-	0.61	0.61
Dicalcium phosphate	-	-	0.59	0.59
Ammonium sulfate	0.46	0.46	-	-
Calcium chloride	0.90	0.90	-	-
Magnesium chloride	0.45	0.45	-	-
Mineral vitamin premix[2]	-	-	0.78	0.78
Chemical analysis, % of DM				
CP	14.9	15.3	16.5	16.8
Soluble protein	32	32	28	28
peNDF	27	27	20	20
NDF	38.6	38.1	32.9	32.6
NFC	38.1	37.4	40.1	39.6
EE	3.6	3.9	4.6	4.8
Ca	1.07	1.25	0.97	1.07
P	0.37	0.45	0.55	0.60
Mg	0.24	0.23	0.28	0.28
NE_l, Mcal kg^{-1}	1.54	1.54	1.64	1.64

[1]Values represent averages of samples composited pre- and postpartum, [2]The mix (DM basis) contained: 0.57% Ca, 15.75% Sulfur, 1,362.24 ppm cobalt, 40816.32 ppm copper, 2724.49 ppm iodine, 10204.08 ppm iron, 122,448.98 ppm manganese, 122,448.98 ppm zinc

Remaining data that were not repeated in time were analyzed by using a generalized linear model (PROC GLM; SAS Inst. Inc.) for a completely randomized design using the following model:

$$Y_{ij} = \mu + T_i + \varepsilon_{ij},$$

Where,

Y_{ij} = Dependent variable
μ = Overall mean
T_i = Treatment effects
ε_{ij} = Residual error.

Means were separated by Duncan multiple range test.

RESULTS AND DISCUSSION

Milk yield was similar between the groups ($p = 0.64$), but it was numerically higher in the supplemented group (Table 2). Milk production increased over time ($p<0.01$) and no treatment×day interaction was detected. Figure 1 shows the milk production trend over the time in the

Table 2: Least squares means of production parameters in cows fed diets containing none (control) or 3.5 and 1.95% fish meal during prepartum and postpartum periods (Supplemented)

	Diets				
	Control	Supplemented	SED	p value	p value time
Milk, kg d^{-1}	36.25	38.73	3.67	0.64	0.002
Fat					
%	4.02	3.9	0.16	0.61	0.002
Kg d^{-1}	1.47	1.50	0.1	0.85	0.85
Protein					
%	2.76	2.73	1.4	0.86	<0.0001
Kg d^{-1}	0.99	1.03	0.09	0.74	0.07
DMI[2]					
Prepartum, kg d^{-1}	11.38	11.68	0.26	0.44	0.0004
Postpartum, kg d^{-1}	18.72	19.13	0.94	0.77	0.09
Body weight[2]					
Prepartum, kg d^{-1}	706.42	693.14	28.3	0.75	0.03
Postpartum, kg d^{-1}	608.18	595.34	21.8	0.61	<0.0001
Body condition score[2]					
Prepartum	3.39	3.33	0.15	0.78	0.01
Postpartum	2.96	2.97	0.09	0.94	<0.0001

[1]Values represent least square means from the first 35 d of lactation, [2]Values represent least square means from 3 weeks before calving (prepartum) and first 5 weeks of lactation (postpartum)

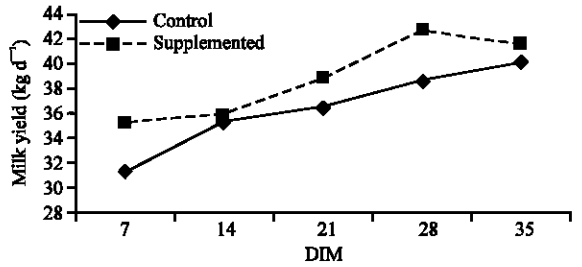

Fig. 1: Effect of diets on weekly means for milk production in cows fed diets containing none (control) or 3.5 and 1.95% fish meal during prepartum and postpartum periods (Supplemented) (pooled SE = 3.3 kg d^{-1})

experimental group during the first 5 weeks postpartum. Milk composition and yields were not affected by diet (Table 2). Our result on milk production is similar to some other reports showing no effect of feeding fish meal on milk production in early lactation dairy cows (Spain *et al*., 1995; Abu-Ghazaleh *et al*., 2001; Mattos *et al*., 2002). Reports in the literature on the effects of feeding fish meal on milk production have not been consistent Abu-Ghazaleh *et al*. (2001) reported that substitution of soybean meal by fish meal in isonitrogenous diet basis at 0, 25, 50 and 100% of supplemental protein did not affect milk yields significantly. Several previous studies reported increased milk yield by adding fish meal (Carroll *et al*., 1994; Adachi *et al*., 2000; Heravi Moussavi *et al*., 2007a). In a review of the literature, Santos *et al*. (1998) observed that milk yield was increased by FM in 8 of 32 studies and cows producing more than 30 kg of milk per day benefited more from FM supplementation than those producing less milk per day. Amount of fish meal supplementation in diet also seems to be another variable in responding cows to fish meal. In a recent study, it was shown that fish meal supplementation just at 5% dry matter intake increased milk production compare with the other amounts of FM supplementation (Heravi Moussavi *et al*., 2007a). In the present study we supplemented fish meal 1.95% DMI in the postpartum period and the milk production was just numerically higher than the control which is in consistent with their result. A numerical increase in milk production in the supplemented group may be due to increased dueodenal flow of nonammonia nonmicrobial N and also lysine and methionine (O'Mara *et al*., 1998). In agreement with this result, another degradability study revealed that soybean protein was highly degradable in the rumen (99.1%), while FM protein was less degradable (76.8%) at 48 h of incubation (Khan *et al*., 1998).

Dry matter intake was similar among the diets both pre- and postpartum (Table 2). Dry matter intake was decreased the week preceding parturition ($p<0.001$). Dry matter intake numerically increased after parturition ($p= 0.09$). The interaction of treatment and time was not significant during pre- and postpartum. Our result on DMI is in agreement with most literature reports that showed little effect of concentration and type of fat supplement on DMI when total fat concentration was below 6% of the DM (Dhiman *et al*., 2000; Petit *et al*., 2001; Akayezu *et al*., 1997). The fact that adding FM to the diet did not decrease DMI was reported previously (Santos *et al*., 1998; Adachi *et al*., 2000; Mattos *et al*., 2002; Heravi Moussavi *et al*., 2007a). In another study it was shown that feeding fish meal from a week preceding calving up to 10 wk postpartum had no effect on DMI (Bruce and Herlugson, 1991). Donovan *et al*. (2000) showed DMI was similar to control when 1% fish oil was added to the diet, but was decreased by adding 3% fish oil. The decrease in DMI was thought to be because of decreased fiber digestion in the rumen or poor palatability. As the amount of FM used in the present study provided less than 0.5% fish oil, this amount did not have any apparent negative effect on DMI both pre- and postpartum.

Milk composition was similar among the groups (Table 2). The effect of time was significant ($p<0.01$) and the fat and protein percentages were decreased over the time. The interaction of diet and time was not significant. Our result on milk fat percentage is similar to previous reports from feeding FM (Polan *et al*., 1997; Adachi *et al*., 2000; Mattos *et al*., 2002; Heravi Moussavi *et al*., 2007a). Meanwhile, some others reported significant reduction in milk fat percentage by adding fish meal (Bruce and Herlugson, 1991; Calsamiglia *et al*., 1995; Spain *et al*., 1995). In another recent study, feeding fish meal up to 5% DMI had no effect on milk fat content and yield

Table 3: Serum metabolite concentration during the week preceding parturition in cows fed diets containing none (control) or 3.5 and 1.95% fish meal during prepartum and postpartum periods (Supplemented)

	Diets			
Parameter	Control	Supplemented	SED	p value
Glucose, mg dL^{-1}	59.0	55.6	6.7	0.73
Serum urea nitrogen (SUN), mg dL^{-1}	15.6	14.0	0.86	0.19
Triglycerides, mg dL^{-1}	29.0	34.8	7.23	0.58
Cholesterol, mg dL^{-1}	108.80	108.71	8.52	0.99

Table 4: Serum metabolite concentration during the first five weeks postpartum in cows fed diets containing none (control) or 3.5 and 1.95% fish meal during prepartum and postpartum periods (Supplemented)

	Diets				
Parameter	Control	Supplemented	SED	Treat. p value	Time p value
Glucose, mg dL^{-1}	51.0	51.52	2.31	0.87	0.12
Serum urea nitrogen (SUN), mg dL^{-1}	15.13	14.0	0.9	0.66	0.18
Triglycerides, mg dL^{-1}	27.84	29.52	4.37	0.79	0.38
Cholesterol, mg dL^{-1}	155.10	145.66	7.0	0.37	<0.01

(Heravi *et al*., 2007a). It was suggested that fish oil is more likely to cause milk fat depression when it is included in diets containing large amounts of fats (Calsamiglia *et al*., 1995) or fed to cows yielding <30 kg of milk d^{-1} (Santos *et al*., 1998).

Our result on milk protein percentage is in consistent with other reports (Polan *et al*., 1997; Mattos *et al*., 2002; Heravi Moussavi *et al*., 2007a). Akayezu *et al*. (1997) reported an increase in milk protein percentages when they included FM at 11% of dietary CP. According to the literature review by Santos *et al*. (1998) cows yielding <30 kg of milk d^{-1} tended to decrease milk protein percentages when fed FM. The protein in FM usually contains greater amounts of total essential AA, especially Lys and Met and its RUP is more digestible in the intestine than are the protein and RUP in the other protein supplements in diets (Akayezu *et al*., 1997). However, Streeter and Mathis (1995) observed no changes in the efficiency of microbial protein synthesis (grams of microbial nitrogen produced/ kilogram of organic matter truly fermented in the rumen) when they added FM to the diet.

Body weight and BCS were similar among the diets during pre- and postpartum (Table 2) which is in consistent with other reports (Bruce and Herlugson, 1991; Heravi Moussavi *et al*., 2007a). The effect of time was significant ($p<0.05$) and body weight and BCS increased prepartum and decreased postpartum. The interaction between time and treatment was not significant.

The effect of experimental diets on some blood metabolites during pre- and postpartum are shown in Table 3 and 4. The blood metabolites were all similar among the groups. Except than cholesterol, the effect of

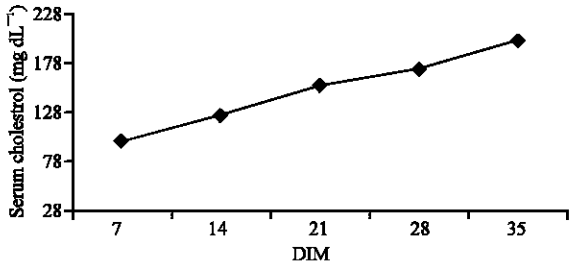

Fig. 2: Trend of serum cholesterol concentration changes during the first 35 d postpartum (pooled SE = 7.14 mg dL^{-1})

time was not significant. Blood glucose was similar among the groups in consistent with other recent report when feeding less than 5% fish meal postpartum (Heravi *et al*., 2007a). In contrast with our study, another study showed that feeding fish oil to dairy cows from prepartum to early lactation reduced plasma concentration of glucose (Mattos *et al*., 2004). The effect of fish oil on glucose concentration in the Mattos study could be due to reduced DMI. In the present study the DMI was similar among the diets and hence the blood glucose was not impacted by diets.

Serum Urea Nitrogen (SUN) was similar among the diets in agreement with other report (Heravi *et al*., 2007a). Previous reports of effects of FM on blood and milk urea nitrogen concentrations have shown inconsistent results. While Abu-Ghazaleh *et al*. (2001) showed that concentrations of serum urea nitrogen decreased as the proportion of FM in the diets increased, that might indicate reduced catabolism of AA in the liver, Broderick (1992) showed that milk urea was higher in cows with supplemental FM. As plasma urea nitrogen and MUN are useful indicators of protein metabolism and status in cows (Roseler *et al*., 1993) dietary differences including the CP content and energy-protein balance in rumen might be responsible for these discrepancies. Recently, it was shown that dietary CP content is the most important nutritional factor influencing MUN (Nousiainen *et al*., 2004). It seems because of adjusting the diets to have close amount of metabolizable protein in the current study, SUN was similar among the diets.

Results of the current study based on the similar serum Triglycerides (TG) level showed that the diets had no apparent impact on fat metabolism. Another study also showed that plasma triglycerides were not affected by FM supplementation (Schroeder and Gagliostro, 2000).

The diet had no effect on serum cholesterol in consistent with another recent report (Heravi *et al*., 2007b). The effect of time was significant ($p<0.001$) and cholesterol concentrations increased after parturition

(Fig. 2) in agreement with another study (Carroll *et al*., 1990). Feeding fat to dairy cattle sometimes increased plasma cholesterol (Fahey *et al*., 2002; Hawkins *et al*., 1995) and the increase is independent of the degree of fatty acid saturation (Grummer and Carroll, 1991) although other study reported no difference (Beam and Butler, 1998).

CONCLUSION

In conclusion, the results of this study demonstrate that dietary supplementation with 3.5 and 1.95% fish meal during pre- and postpartum periods had no apparent effect on milk production and composition and dry matter intake in early lactation dairy cows. Adding fish meal to the diet did not exert general metabolic effects as plasma concentrations of glucose, SUN, cholesterol as well as serum TG were similar among dietary groups.

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