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Effect of feeding fish meal on milk production and its composition in dairy cows

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ABSTRACT

An experiment was conducted to evaluate the different levels of the feed ration of milking cows on milk production and its composition. The research was carried out in Gorgan city vicinity on lactating dairy cows (12), which were similar in number of calving and other parameters in a randomized complete design with 4 rations. The fish meal levels 0, 1, 2 and 3% (on the dry matter basis).

Average daily milk yield were 21.30, 22.50, 22.48 and 23.12 kg/day for all the diets respectively, which all the diets were greater than control groups. Fat percentage and fat content of milk also were not affected by the diets composition. Body weight gain (g/d) of treatment 4 and 3 were significant over treatment 1 and 2. Dry matter intake for milk yield (kg/d) in treatment 1 was slightly higher than the other treatments ($P<0.05$). In the same way fat, protein and lactose percentage of different treatments were almost similar to each other, but no others significant effects were observed.

Key words: Dairy cattle, Fish meal, Milk composition, Milk yield

A high producing dairy cow in early lactation requires 18 to 19% CP in the diet to support milk production (Carroll *et al*. 1994). Because profits are related to reproductive performance as well as milk production, existence of a negative relationship between excessive dietary protein (>19%) and fertility could be an important consideration. Results of studies investigating the relationship of fertility and CP concentration have been varied (Atwal and Erfle 1992). Supplementation of FM at under 4% of the dietary DM can stimulate increased milk production without decreasing milk fat content (Broderick 1992). Also Research has shown that properly processed fish meal (FM) is highly resistant to rumen degradation and has an excellent AA profile in terms of ruminant needs (Atwal and Erfle 1992).

Modification of ruminant diets to achieve more helpful meat and milk products is an attractive area of research for nutritionist. The use of marine lipids in this pursuit was investigated in dairy cattle diets in the 1970s, but most of this research was abandoned when the concomitant decline in milk fat content was perceived as a negative side effect to dairy producer that were compensated on a milk fat basis (Doreau and Chilard1997). The potential human health benefits of specific FA, including benefits for docosahexaenoic acid (DHA), conjugated linoleic acid (CLA) (Roche *et al.* 2001) and eicosapentaenoic acid (EPA) have been identified. Milk fat composition can be modified by direct addition of fatty acid (FA) supplements to milk or milk products, by genetic manipulation, or by feeding special diets to dairy cows. Direct supplementation has the advantages of simplicity and that theoretically, any level of desired FA could be added to milk fat. Further, supplemental FA must be blended with milk fat and then homogenized into skimmed milk, a process that is undesirable for cheese making because homogenization produces cheese with excessive moisture content and reduce firmness (Fox *et al.* 2000). Diets supplemented with FM increased DHA concentration in milk and also decreased milk fat content and total fat production (Sutton 1989, Spain and Polan 1995, Wright *et al.* 1998, 2003 and AbuGhazleh *et al*. 2004, 2007). Cunnane (2000) has described DHA as appearing to be conditionally indispensable for infants under 2 years of age for brain functioning and visual acuity. Because rapidly growing or lactating ruminants with high milk production require an amino acid (AA) supply in addition to that produced by ruminal microbes, fish meal can be used for supplementing their diets. However, results of performance data published in the last two decades using fish meal as the major protein supplement have been inconsistent (Hussein and Jordan 1991, Doreau and Chilard 1997, Wright *et al.* 2003 and Whitlock *et al.* 2006).

MATERIALS AND METHODS

Holstein cows (12) were blocked by weight and assigned

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randomly to a 2 × 3 factorial arrangement of treatments in a randomized complete block design with 3 cows in each treatment. The barn dimensions were 4.3 m × 7.4 m with automatic waters located near the feed bunk and shared by 2 barns. The treatments combined no supplemental fish meal, as control group, 1% fish meal as group 2, 2% fish meal as in group 3 and 3% fish meal as group 4, respectively. All diets met or exceeded the minimum requirements for CP, Ca, and P. The commercially procured fats were supplied. Wheat-based diets were chosen to facilitate an optimally low ruminal pH. Managemental aspect like ear tagging; vaccination for blackleg and malignant oedema, infectious bovine rhinotra cheitis with parainfluenza-3 (modified live) and bovine virus diarrhea; implanted with 24 mg estradiol; and treating with anathematic and grubicide. Decoquinate at 180 mg vitamin A at 40,000 IU/d, and vitamin E at 200 IU/d were included in the receiving diet (25% concentrate, 75% roughage) for 15 day. The experiment was conducted for 120 days. The trial began (day 0) with weighing the steers and increasing the diet to 50% concentrate for 7d, then to 72% concentrate (with 2% added fish meal in designated treatment diets) for 4 d, and finally to 85% concentrate (Table 1 and 2). Cows were fed twice daily throughout the trial and were milked twice daily at 0600 and 1700 h, and milk yields were recorded daily. Individual milk samples were collected from consecutive milking (a.m. and p.m.) once weekly and analyzed for fat,protein,lactose. Starting and ending weights were the average of 2 consecutive early- morning weights. The cows were weighed at 28-day intervals until 120 days. Cows were weighed at 07.00 am and fed upon treatment diets (3 animals/treatment). Data were analyzed as a randomized complete block design with a 2×3 factorial arrangement of treatments using pen as the experimental unit. The model included fat, Ca, and their interaction as treatment effects, with weight as a blocking factor (Cochran and Cox 1962). When interactions were not significant ($P > 0.10$), the df associated with fat were further partitioned using orthogonal contrasts. When interactions were present, means were separated by least significant difference. Statistical analyses were performed using the GLM procedure (SAS 1998) with $P<0.10$ as the accepted level of significance. Thus the objective of this experiment was to determine the management of feeding fish meal on milk production and its composition in dairy cows.

Table 1. Composition of diets (% of DM)

Ingredients and Composition	Rations			
	T4(3)	T3 (2%)	T2 (1%)	T1 (0%)
Wilted alfalfa	17.10	17.10	17.10	17.10
Corn silage	16.20	16.20	16.20	16.20
Wheat grain	35.70	37.00	38.40	39.00
Cottonseed meal	17.60	18.30	18.94	19.00
Wheat bran	6.50	6.70	5.90	7.00
Fish meal	3.00	2.00	1.00	0.00
Salt	0.18	0.18	0.17	0.29
Sodium bicarbonate	0.00	0.50	1.00	0.00
Calcium bicarbonate	1.00	1.02	1.29	1.30

Table 2. Chemical composition of diets and nutrient digestibility

Chemical Composition	Rations			
	T4(3)	T3 (2%)	T2 (1%)	T1 (0%)
DM %	81.68	82.10	81.85	81.99
CP % of DM	20.20	20.00	19.40	19.00
ADF % of DM	19.20	18.90	18.70	19.00
NDF % of DM	32.80	32.20	32.20	32.80
GE,Mcal/kg DM	1.63	1.63	1.62	1.62
Nutrient digestability				
Ca %	0.87	0.83	0.87	0.83
P %	0.61	0.59	0.56	0.54
Ca : P	1.42	1.40	1.55	1.56

RESULTS AND DISCUSSION

Dietary ingredients and nutrient compositions are presented in Table 1. In this experiment the total amount of raw milk produced from all the different treatments were 21.30,22.50,22.48 and 23.12 kg/day, respectively (Table 3),in which addition of fish meal in this ration increased the total milk yield production significantly ($P<0.05$).The fish meal was high in undegraded intake protein (UIP).A nylon bag assay with rumen cannulated sheep showed that after 24 h of incubation, 20.3% of DM and 18.2% of CP were degraded from fish meal. When added at 41% CP to a TMR, this fish meal should have provided 3.4% UIP.

The digestibility of dry matter in treatment 3 was highest (82.10) and those of gross energy (GE) in treatment 3 and 4 (1.63 and 1.63) and ADF of treatment 4 (19.2) were highest among other treatments (Table 2).The CP digestibility was high in treatment 4 (20.20%). Nevertheless, the differences in DM, GE, ADF, NDF and CP digestabilities for all the 4 diets were not significant. The DMI was highest for the treatment 1 (0.58kg/d) and means for the 4 treatments differed significantly from one another (Table 2).However , treatment 4 produced more milk than others.

Fat percentage of treatment 4 increased, but lactose percentage decreased on treatment 3.The highest daily production of fat (0.770 kg/g) in treatment 3, protein (1.62 kg/d) in treatment 4 and lactose (1.22 kg/d) in treatment 4 was also observed. Cows showed maximum body weight gain (0.643 g/d) during the period for treatment 4 diet compared with other treatments, respectively.

The large difference might suggest that fish meal feeding enhanced utilization of energy for milk production, probably by increasing the availability of amino acids (AA).However

Table 3. Least squares means of BW gain, DMI, milk production and milk components

		Rations			
SE		T4(3)	T3 (2%)	T2 (1%)	T1 (0%)
BW Gain,g/d	3.12	0.643^a	0.610^a	0.350^b	$^a0.575$
DMI,kg/d	4.42	0.52^b	0.570^a	0.520^b	0.580^a
Milk production,kg/d	6.98	23.12^a	22.48^a	22.50^a	21.30^b
Fat,%	0.13	3.94^a	3.80	3.57	3.39
Protein,%	6.93	3.32	3.27	3.21	3.18
Lactose,%	57.42	4.30^b	4.18^c	4.14^d	4.35^a
Fat,kg/d	1.21	0.63	0.77	0.76	0.63
Protein,kg/d	1.13	1.62	1.41	1.51	1.42
Lactose,kg/d	3.18	1.22^a	0.96^c	1.00^b	1.02

a, b, c superscript in the column differ significantly (P<0.05).

body weight changes in short periods may not be fully reliable and need to be interpreted with caution.

Digestabilities of DM and NDF in our study were close to the values reported by Carty *et al.* 1989 for corn- based diets (15% CP). In both experiments the digestibility of DM was not any lower for the fish meal diets. Also a decrease in DMI in treatment 2 and 4 is confirmed by the similar observations of others (Klusmeyer *et al.* 1990, Oldham *et al.* 1985, Wohlt *et al.* 1991, Carroll *et al.* 1994 and Wright *et al.* 2003). The objective of giving feed with high UIP, like fish meal, is to increase the duodenal supply of AA, which would alter the pattern of use of absorbed nutrients, i.e., protein-energy interrelationships in the body. Many workers (Oldham 1984, Atwal 1992, Sutton 1989 and Amanloo 2004) reviewed these aspects in detail and suggested that, for high milk production, the ratio of grams of AA N: megajoules of metabolizable energy (ME) in the nutrients absorbed from the gut should be close to 1.2. Even when cows were in negative energy balance, an increase in absorbed AA N increased FCM production by increasing body fat metabolization (Whitelaw *et al.* 1986). When the cows attained their maximal capacity for lipolysis of adipose tissue, a further increase in absorbed AA N increased the volume of milk produced by supplying gluconeogenic substrates for lactose synthesis, but there was no increase in energy output of milk**.** However AbuGazaleh (2004 and 2007), reported that milk production increased in cows fed fish meal diets and also milk fat and milk protein percentages decreased with fish meal diets.

In our study, in spite of reduced DMI by feeding the FM diet, this diet supplied 795 g/d of FM protein. This increase compares favorably with the 1.3 kg increase in 3.5% FCM reported for 450 g of FM protein substituted for SBM protein (Broderick 1989). In some studies, increases of 1.1 to 2.6 kg/d of milk were observed when FM replaced other proteins (6.25) or urea (Wright *et al.* 1998), but the differences were not significant. Still, in a few other studies, in which cows produced less than 27 kg/d of milk, feeding of FM failed to increase milk production at all (Erfle 1983, Oldham 1985, Sloan 1988 and Wright *et al.* 1998) or even resulted in a decrease of FCM production (Erfle 1983). Furthermore Whitlock *et al.* (2006) concluded that the low fish oil diet was as effective at increasing VA and CLA in milk as the high oil diet, showing that only low concentrations of dietary fish oil are necessary for increasing concentrations of VA and CLA in milk.

It can be rationalized that FM-based diets were adequate to meet the AA N requirement of cows producing less than 22 kg/d of milk and that the use of FM did not increase milk production but rather diverted some energy for body tissue deposition and decreased the milk fat percentage (McCarthy 1989 and Wright *et al.* 2003). However, in moderately high producing cows, FM feeding increased milk and milk fat production, likely in response to an increase in the ratio of absorbed AA N: ME. DePeters and Palmquist (1990) observed an increase in the percentage of milk N, pointing to some increase in absorption of AA. But the change in AA N: ME ratio, perhaps, was not adequate for a significant increase in milk production.

McCarthy *et al.* (1989) reported that feeding of FM, high in oil (12.9%) and at high levels of FM (8.4% CP) in a 15.4% CP diet, decreased microbial protein production and failed to increase the total supply of AA N to the duodenum. The significant increase in the percentage of fat and decrease in the percentage of lactose of milk in response to feeding the FM diets in our study are similar to earlier results (DePeters *et al.* 1990 , Sloan *et al.* 1988, Pabst *et al.* 1986, Atwal and Erfle 1992, Spain and Polan 1995, Wright *et al.* 2003 and Amanloo 2004). These data suggest that, even for FM diets, energy supply was adequate, but AA N supply limited any further increase in FCM production.

A significant increase in daily production of milk and milk protein by feeding a high protein FM diet showed that the FM diet (15.5% CP) was not adequate for maximizing production. A significant increase in FM diet seems to indicate more favorable conditions for microbial activity. Hoover (1986) suggested that, for current feeding practices for lactating cattle, rumen ammonia requirement may exceed 5 to 10 mg/dl. Reducing FM in diets to change CP from 14.5 to 11.0% decreased rumen ammonia from 10.5 to 2.5 mg/dl (Klusmeyer *et al.* 1990). Our FM diet contained 4.1% CP as FM and 11.4% CP from other ingredients. Thus, the supply of ammonia, other nutrients, or both in the rumen of cows fed FM diet may be marginal to maximize microbial activity.

In conclusion, addition of highly undegradable FM to a high energy diet increased milk production of cows producing a moderate level of milk, and it reduced BW gain. For maximum activity of rumen microbes, FM diets should contain at least 11.4% CP from other ingredients. Even when FM was added to increase the CP of TMR, the energy supply was adequate, and further increase in milk production may have been limited because of AA supply. Thus, there is a good reason for feeding FM or protected protein of good quality to cows producing more than 25 kg of milk.

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