Effect of Feeding Saturated Fat on Milk Production and Composition in Crossbred Dairy Cows

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ABSTRACT : To see the effect of Beragfat T-300, a by pass fat, on the production and composition of milk, four primiparous crossbred cows in their early lactation were used in a 4×4 Latin Square Design. Each period was of 30 days including 15 days of adjustment period. The diets were formulated to contain 0, 2.5, 3.5 and 4.5% of Bergafat and were isonitrogenous and isoenergetic. The intake of DM, OM, CP, NDF, ADF, Cellulose and ADL were not affected, however, the EE intake was increased by the supplementation of Bergafat in the diet of cows. The digestibilities of NDF and EE remained unaffected, whereas the digestibilites of DM, OM and CP were reduced. Milk yield remained unaltered, while 4%FCM yield increased as a result of adding Bergafat in the daily ration. Bergafat upto 4.5% of the diet DM can be added in the diet of crossbred cows without any adverse effect on the DM intake and digestibilities of DM and NDF. Furthermore, Bergafat does not cause any butter fat depression in the milk of cows. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 2 : 204-210)***

Key Words : Bergafat, Lactation, Digestibility, Neutral Detergent Fibre

INTRODUCTION

Nutrient requirements of high producing dairy animals especially during early lactation often exceed the capacity of ruminal fermentation and protein synthesis. Rising milk yield during early lactation presents a feed problem in dairy cows as the peak milk yield occurs at 6 to 8 weeks post-partum whereas the maximum feed intake lags behind peak milk yield by several weeks. This disparity between the timing of maximum daily energy output (milk and its components yield) and maximum feed intake during the first 150 days of lactation usually gives rise to an energy deficit of varying level. Under this condition, animals usually have to draw upon their own body reserves to support the large volume of milk, resulting into weight loss, ketosis and fertility problems (Grummer, 1988).

There are many alternatives to overcome these problems. One of them is feeding of concentrates to dairy animals. Feeding fat to lactating animals is another alternative as it provides a dense source of non-fermentable energy (Sarwar et al., 1999). In this way, animal can get more energy at low dry matter intake. However, fat feeding presents certain problems. Unsaturated fatty acids strongly inhibit activity of carbohydrate-splitting microorganisms which can interfere rumen function. To counteract the undesirable effect of unsaturated fatty acids on the ruminal fermentation, these have been fed as salts of calcium (Jenkins and Palmquist, 1982; Chalupa et al., 1984; Jenkins and Palmquist, 1984; Chalupa et al., 1986). Fats, as salts of long chain fatty acids (Ca-LCFA) improve rumen fermentation and have increased digestibility (Brumby et al., 1978; Jenkins and Palmquist, 1984; Schneider et al., 1988), BERGAFAT T-300 is a protected fat and does not influence rumen microorganisms. It is produced from palm oil, and is available as flaked powder. It includes approximately 8% oleic acid which softens milk fat and also includes $C_{16:0}$+ $C_{18:0}$ up to 85% with melting point of 56-60°C. The objective of the study was to examine the influence of this bypass fat on milk yield and its composition of early lactating dairy crossbred cows.

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MATERIALS AND METHODS

Diets and animals

Four primiparous crossbred (Sahiwal×Holstein Fresian) cows in early lactation were used in a 4×4 Latin Square Design. Cows were housed on concrete floor in separate pens. Four experimental diets were formulated (Table 1). The control (C) diet was formulated to have 0% bypass fat (bergafat t-300). The LF, MF and HF diets were formulated to have 2.5, 3.5 and 4.5% bypass fat, respectively. All diets were formulated to be isonitrogenous and isoenergetics using NRC (1988) values for energy and protein in concentrates. Wheat straw was analyzed for NDF and CP and NE_L was estimated prior to diet formulation. Diets were mixed daily but fed twice a day for *ad libitum* intake (10% feed refusal). Cows were fed for four periods, each of which lasted for 30 days in which first 15 days served as adjustment period and the last 15 days for data collection.

Sample collection and analysis

Daily feed intake and milk production were averaged over the last 15 days. Milk samples (a.m. and p.m.) were taken for each day of each collection period. Diets and orts were sampled daily from each period and composted by

Table 1. Ingredient composition of experimental diets ingredients (%DM)

Diets*	C	LF	MF	HF
Wheat straw	40.0	40.0	40.0	40.0
Cotton seed meal (36%)	2.0	22.7	20.6	30.0
Corn gluten meal	13.3	11.3	13.3	3.0
Wheat bran	2.0	2.8	7.8	7.8
Rice polishing	19.1	8.8	2.8	2.8
Molasses	10.0	10.0	10.0	10.0
Corn grains	10.7	-	-	-
Fat	-	2.5	3.5	4.5
Dicalcium phospate	1.0	2.0	2.0	2.0
Urea	2.0	-	-	-
Total	100	100	100	100

* C, LF, MF and HF stand for 0, 2.5, 3.5 and 4.5% fat respectively.

periods for analysis. Faecal grab samples were taken twice daily such that a sample was obtained for every three hours of 24 h time period (8 samples). Digestibility was determined by the acid in soluble ash marker ratio technique of Van Keulen and Young (1977).

Diet offered, orts and fecal samples were dried at 65°C and ground through Wiley mill and then were put in plastic bottles for later analyses. Diet offered, orts and fecal samples were analyzed for dry matter, organic matter, crude protein using methods described by AOAC (1990) and neutral detergent fiber, acid detergent fiber and acid detergent lignin by the methods of Van Soest et al., (1991). Milk samples were analyzed for crude protein by the method described by AOAC, (1990) and fat by Gerber's method.

The data collected on different parameters, were analyzed statistically using Analysis of Variance Technique (Sokal and Rohlf, 1995).

RESULTS AND DISCUSSION

Composition of feeds

All diets were iso-energetic and iso-nitrogenous however, CP contents ranged from 14.70 to 15.20%. Wheat straw (40%) and molasses (10%) were kept constant in all the diets (Table 2). Dry matter percentage was nearly same across all the diets ranging from 89.30 to 90.30. Similarly, organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose and acid detergent lignin (ADL) contents were not different among diets. However, ether extract (EE) and ash percentages increased as fat percentage and dicalcium phosphate in diets increased.

Table 2. Chemical composition of experimental diets

Items (%)	C	LF	MF	HF
Dry matter	89.3	90.0	90.1	90.3
Organic matter	93.8	92.5	92.1	92.1
Crude protein	14.7	15.0	14.7	15.2
Ether extract	3.0	5.8	6.9	7.2
Crude fiber	18.2	21.2	21.3	21.3
Ash	6.2	7.5	7.9	7.9
Neutral detergent fiber	39.3	37.9	41.3	38.6
Acid detergent fiber	23.3	22.8	23.7	22.9
Cellulose	16.8	16.6	17.3	16.7
Acid detergent lignin	5.9	5.8	5.9	5.9

* C, LF, MF and HF stand for 0, 2.5, 3.5 and 4.5% fat respectively.

Feed intake

The DM, OM, CP, NDF and ADF intakes of cows were not affected with increased level of Bergafat in the diets (Table 3). However, EE intake increased linearly with increasing fat level in diets. Inclusion of fat in the diet has a variable effect on the DM, OM, CP, NDF, and ADF intake of ruminants. In studies by Grummer, 1980; Jenkins and Jenny, 1989; Schauff and Clark, 1992; Tackett et al., 1996; Jones et al., 2000, the intake was not affected by inclusion of fat in the diets. However, other workers (Son et al., 1996; Simas et al., 1997; Rodriguez et al., 1997; Bertrand and Grimes, 1997; Pantoja et al., 1996) reported decreased DM, OM, CP, NDF and ADF intakes with increasing fat in the diets. The probable reason for decrease in intake may be unsaturated fats, which adversely affected ruminal fermentation. Another reason for low intake was higher inclusion of fat, in most cases, affecting palatability of diet. However, in our study, the fine texture and absence of any smell of Bergafat may not have affected the DMI by cows. Highly saturated fatty acid contents (Palmitic and Stearic acid>85%) may be another reason for not affecting DMI as these did not affect ruminal fermentation.

Digestibility

The NDF and EE digestibilities remained unaltered, however, DM, OM and CP digestibilities were decreased with increasing level of fat in the diet (Table 4). Effect of added fat on the digestibility of the feed ingredients is variable.

Table 3. Effect of bergafat T-300 on DM, OM, CP, EE, CF, NDF, ADF, cellulose and ADL intake

Items (%)	Diets				
	C	LF	MF	HF	SE
Intake, kg/d					
DM	11.8	11.8	11.5	12.3	0.554
OM	11.3	11.1	10.9	10.6	0.500
CP	1.8	1.8	1.7	1.9	0.078
EE	0.5	0.6	0.8	0.8	0.083
CF	2.2	2.5	2.5	2.6	0.130
Ash	0.7[a]	0.9[a]	0.9[a]	1.0b	0.042
NDF	4.6	4.5	4.8	4.7	0.208
ADF	2.7	2.7	2.7	2.8	0.884
Cell	2.0	2.0	2.0	2.1	0.092
ADL	0.7	0.7	0.7	0.7	0.030

* C, LF, MF and HF stand for 0, 2.5, 3.5 and 4.5% fat respectively.
Means within a row with different superscripts differ significantly ($p<0.05$).

Table 4. Effect of bergafat t-300 on DM, OM, CP, NDF and EE digestibility

Items	Diets				
	C	LF	MF	HF	SE
Digestibility (%)					
DM	57.1[a]	56.0[b]	56.1[ab]	55.4[b]	0.003
OM	59.7[a]	58.5[b]	58.7[b]	58.0[b]	0.265
CP	73.7[a]	71.9[b]	70.7[b]	71.5[b]	0.512
NDF	63.4	62.6	63.4	62.4	0.829
EE	80.0	80.1	80.4	80.7	0.503

* C, LF, MF and HF stand for 0, 2.5, 3.5 and 4.5% fat respectively.
Means within a row with different superscripts differ significantly ($p<0.05$).

Bertrand and Grimes (1997) reported decreased NDF digestibility, in total tract, in cows fed 5.6% added tallow in the dairy cows ration. The possible reasons for reduced NDF digestibility in aforementioned study was perhaps due to use of unprotected fat in form of oil, tallow, commercial blended fats and fats in form of soybeans, and fat inclusion rate>5% in diets. But in our case, ruminally protected fats with increased melting points, increased the ratio of saturated fatty acids and fat inclusion rate not exceeding 4.5% eliminated their bad effects on ruminal fermentation and fiber digestibility.

Jenkins and Palmquist (1984) and Sharma et al. (1978) reported no change in the digestibility of total FA as a percentage of intake in cows fed supplemental fats. Partially hydrogenated tallow fat and canola oil when fed in combination showed higher FA digestibilities than when fed separately (Jenkins and Jenny, 1992). Simas et al. (1995) and Palmquist and Conrad (1978) also reported improved EE digestibility in animals fed supplemental fats. This higher digestibility of FA is probably due to increased absorbing efficiency of FA of high melting points (Steele, 1983).

Digestibility of DM was decreased by feeding raw whole soybeans or heated whole soybeans at 20% of dietary DM (Mohammad et al., 1988). Klusmeyer et al. (1991b) also reported decreased DM truly digested in rumen of cows fed Ca-FA. On the other hand, Simas et al. (1995) reported improved DM, OM, and starch digestibility in early lactating cows fed Ca-LCFA in diets. Stern et al. (1985) found no significant difference in OM digestion of two different diets containing whole soybean and soybean meal separately. Supplemental lipids did not depress OM digestibility in total gastrointestinal tract (Tamminga, 1981). True digestibility often decreases at higher intake, apparently due to limited absorptive capacity by ruminants (Bines et al., 1978).

Protein digestion either decreased or not changed by adding fat to the diets of ruminants (Jenkins, 1990; Grummer, 1988; Graiger et al., 1961; Boggs et al., 1987). However, Palmquist and Conrad (1978) reported increased CP digestibility due to high fat feeding except ADF whose digestibility was not decreased significantly.

Milk yield

Average milk production remained unaltered across all treatments (Table 5). Similar results have been reported by other workers (Finn et al., 1985; Ferguson et al., 1988; Schneider et al., 1988; Hoffman et al., 1991; Klusmeyer et al., 1991b; Erickson et al., 1992; Jenkins and Jenny, 1992; Pantoja et al., 1996; Solomon et al., 2000; Weiss and Wyatt, 2000) in which fat supplementation did not increase milk yield. Jones et al. (2000) also reported no effect on milk yield when cows were fed diets containing tallow and fish oil. however, there are studies in which milk production has been increased as a result of supplemental fat feeding (Grummer, 1988; Johnson et al., 1988; Kent and Arambel, 1988; Jerred et al., 1990; Schauff et al., 1992b; Boila et al., 1993). Shaver (1990) observed average increase of milk about 1.5-2 kg/d/cow by feeding 0.45 kg of supplemental fat. Khorasani et al. (1991) observed that whole canola seed included at up to 5% of dietary DM had a positive effect on milk yield. Fat supplementation increases milk production perhaps due to greater NE_L intakes (Andrew et al., 1991; Eastridge and Firkins, 1991). Jenkins and Palmquist (1984) and Palmquist (1984) observed that supplemental fat increased milk production only when it was added up to 6% of dietary DM but decreased in milk production was noted when fat level exceeded from 6%.

FCM yield

The cows fed Berga fat had higher 4% FCM yield than the control group (Table 5). These results supported the findings of other workers (Johnson et al., 1988; Jenkins and Jenny, 1992; Sklan et al., 1992; Harrison, 1991; Canale et al.,1992a; Son et al., 1996; Maiga et al., 1995). Weiss and Wyatt (2000) reported increased FCM yield, when high oil corn silage was added in diet however DMI was not influenced. The reason for increased FCM in the present study is because of increased milk fat test in cows fed diets containing fat.

In contrast to present results, other workers reported no effect on 4% FCM yield (Johnson et al., 1988; Casper et al., 1990; Kent and Arambel, 1988; Salfer et al., 1995; Elliott et

Table 5. Effect of bergafat on milk yield and its composition

Items	Diets				SE
	C	LF	MF	HF	
Milk yield (lit/d)	12.7	12.7	13.3	12.9	0.481
4% FCM Yield (lit/d)	12.2	14.6[a]	15.4[a]	15.4[a]	0.606
Composition (%)					
Fat (%)	3.7[c]	5.0[b]	5.1[b]	5.3[a]	0.056
CP (%)	3.3	3.3	3.3	3.4	0.022

* C, LF, MF and HF stand for 0, 2.5, 3.5 and 4.5% fat respectively.
Means within a row with different superscripts differ significantly ($p<0.05$).

al., 1993). Salfer et al. (1995) reported that milk and 3.5% FCM yields were not influenced when supplementation of dietary partially hydrogenated tallow (2%) was initiated prepartum or at parturition. Elliott et al. (1993) fed dairy cows diets containing 2.5 or 5% tallow and observed no significant effects of dietary fat on production of milk and 4% FCM.

Milk composition

Milk fat : Milk fat percentage was highest at 4.5% added Bergafat and lowest in the control (Table 5). The increased fat percentage by supplementation of Bergafat supported the findings of other workers (Storry and Rook, 1963; Finn et al., 1985; Ferguson et al., 1988; Schneider et al., 1988; Hoffman et al., 1991; Klusmeyer et al., 1991b, Erickson et al., 1992; Jenkins and Jenny, 1992; Pantoja et al., 1996; Solomon et al., 2000; Weiss and Wyatt, 2000) in which supplemental fat in the diet of cows increased their milk fat percentage.

Being highly saturated in its composition and direct relationship of dietary fatty acids with milk fat, Bergafat caused increased milk fat synthesis. The probable reason for increased milk fat percentage might be the linear relationship between dietary, plasma and milk FA (Moore et al., 1969). Another reason for increased milk fat percentage was that increased dietary fat enhanced supply of FA to mammary gland from feed, which resulted in lower proportion of denovo fat synthesis. Milk fat, milk protein, milk yield and mean body condition score increased linearly with increased fat saturation (Pantoja et al., 1996).

Some workers have reported no change in milk fat percentage of the animals fed supplemental fat. Brown et al. (1962) reported that 6% added tallow or cottonseed oil had no effect on milk fat percentage and milk yield. Moody et al. (1967) reported that vegetable oil or hydrogenated fat in the concentrate of cows kept at high temperature (32°C), had no effect on milk or milk fat production.

In other studies, supplemental fat in the diet of cows depressed their milk fat percentage (Nicholson and Sutton, 1971; Rindsing and Schultz, 1974; Storry et al., 1974a; Storry et al., 1974b; Pennington and Davis, 1975; Palmquist, 1983 and Grummer, 1991). Larson and Wrenn (1978) reported that milk fat percentage was decreased when unprotected tallow was fed to dairy cows. The possible reason for decrease in milk fat content may be increased supply of polyunsaturated FA in the diets of cows, which adversely affected the ruminal fermentation, reduced NDF digestibility, reduced acetate: propionate and reduced availability of acetate to mammary gland. Another reason for decreased fat percentage in milk may be the reduced supplying of fiber to animal when added fat is replaced with hay or forage in the diet. In the mammary gland, acetate is the major precursor of FA synthesis and a highly digestible fiber source is required to maintain the concentration of milk fat. Minimum effective NDF (19-21%), derived from some forage source, is required to prevent the reduction of milk fat (Fox et al., 1992). Storry and Rook, (1964) also found lower milk fat contents with increased proportion of unsaturated acids in milk fat when animals were fed diets low in hay and high in flaked maize.

Milk CP : Milk CP was highest in the milk of cows fed HF diet and lowest in the control (Table 5). These results supported the results of previous studies (Chan et al., 1997; Harrison et al., 1995; Dunkley et al., 1977; Firkins and Eastridge, 1992) in which supplemental fat increased milk protein.

Chan et al. (1997) suggested that amino acid profile of rumen undegradable protein (RUP) while feeding fat to animals is important to prevent a decrease in milk protein content of cows fed supplemental fat. A significant increase in casein concentration in response to dietary protected tallow was noted by Dunkley et al. (1977). Pantoja et al. (1996a) reported that milk protein percentages were not affected by supplementation with 5% saturated tallow, or animal vegetable fat but increased linearly with increased fat saturation. The probable reason for slight increase in milk protein percentage in present study may be the proper supply of amino acids in the diets as DM intake was not decreased by fat diets. While formulating diets, addition of a good concentration of bypass protein by adding different bypass protein sources like cottonseed meal, corn gluten meal and corn grains might be another reason for increased protein percentage in fat diets.

Supplemental fat in the diet of cow did not affect milk protein contents in studies by DePeters et al. (1989); Hermansen (1989a); Palmquist and Conrad (1978); Eastridge et al. (1988); Kim et al. (1991) and Grummer (1988). DePeters et al. (1989) reported no effect of animal fat on milk composition (milk fat, protein, lactose and SNF). Jerred et al. (1990) examined the effects of feeding 0 or 5% prilled fat in early lactating cows and found that fat supplementations did not cause a negative effect on milk protein yield. The probable reason for not increasing protein contents may be improper ratio of bypass protein with bypass fat in animal diets. Palmquist and Moser (1981) reported that dietary fat impaired amino acid transport into the mammary gland and milk protein synthesis. There may be many reasons for decrease in protein concentration in milk. Wu and Huber (1994) suggested that due to poor DMI providing insufficient amounts of critical amino acids for milk protein synthesis, milk protein depression happened as milk synthesis increased. They also argued that higher DMI with higher saturation might improve the situation.

CONCLUSION

The study was conducted to examine the influence of varying levels of bypass fat on the milk yield and its composition of lactating crossbred cows. Four lactating cows were used in a 4×4 Latin Square Design. The dry matter intake was not affected by feeding different levels of fat. Similar pattern was observed regarding the intakes of organic matter, crude protein, crude fiber, neutral detergent fiber, acid detergent fiber, cellulose and acid detergent lignin. However, ether extract and ash intakes increased as fat level in the diet increased. The DM, OM and CP digestibilities were reduced in the cows fed diets containing Bergafat. However, NDF and EE digestibilities remained unaltered. This indicates that Bergafat does not have any adverse effect on fiber digestibility. Milk yield remained unaltered across all the treatments. However, percent milk fat increased in cows fed diets containing Bergafat. The reason for lack of response in milk yield may be that our diets have not supplied an ample amount of bypass protein or the animals had already reached their maximum potential of production. This needs further investigation.

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