Proc. 3rd All Africa Conf. Anim. Agric. & 11th Conf. Egyptian Soc. Anim. Prod., Alexandria, Egypt, 6-9 November 2000: 143-148

FAT SUPPLEMENTATION AND ITS EFFECT ON MILK YIELD, MILK COMPOSITION AND THE FEEDING VALUE OF DAIRY COW'S DIET

S.T. M. Fahmy, A.K. I .Abd El-Moty, E.B. Soliman and E.M. Ibrahim

Department of Animal Production, Faculty of Agriculture, Minia University, Minia, Egypt

SUMMARY

Six multiparous lactating dairy Friesian cows of 459.5 ± 13.7 kg body weight were used in this study in switch back arrangements. Three experimental diets (T1,T2 andT3) were fed in amounts to meet the AFRC 1993 requirements for maintenance and production of these cows. Dietary fat (poultry grease) was added daily to the concentrate mixture before feeding in amounts that represent 0, 10 and 15 % of AFRC metabolizable energy standards to diets T1, T2 and T3 respectively. The concentrate mixture was composed of 50 % corn, 40 % wheat bran, 7 % soybean meal, 2 % calcium carbonate and 1 % salt (Nacl). Wheat straw, the roughage source, was fed *ad lib*. Feeds were offered twice daily after milking at 9 a.m. and 6 p.m. Water and mineralised salt blocks were available all the day along the experimental period. Milk yield and composition, nutrients digestibility and the feeding value (TDN%) were determined. Results indicated that fat supplementation increased ($P < 0.05$) milk yield from 12.8 to 16.4 kg /d (28.1% enhancement) when T1 was compared with T3. The improvement was greater (42.5%) considering the fat corrected milk (40 g fat /kg^{-1}). The figures were 12 vs. 17.1 kg for T1 and T3, respectively. The protein yield was also improved ($P < 0.05$) from 0.42 to 0.58 kg / d with a 38.1 % increment (T1 vs. T3). All digestibility coefficients were enhanced ($P < 0.01$), except the nitrogen free extract where the increment was significant ($P < 0.05$). The feeding value (TDN) of the tested diets were 67, 72.7 and 77.5 % for T1, T2 and T3 respectively. The differences were significant ($P < 0.01$) and the improvement was 15.7 % when T1 was compared with T3.

Keywords: Dairy cows, dietary fat, digestibility, milk yield

INTRODUCTION

Nutrient requirements of lactating cows varies according to several factor such as breed, production level, physiological stage and milk composition. Energy is the major feed nutrient that should be supplied in highly metabolisable form and in amounts that meet cows requirements. Fat as a feed ingredient is the highest energy density source among other feed ingredients . Using different kinds of fat. such as oily seeds, tallow, triglycerides, prilled fatty acids, long chain fatty acids and calcium salt of fatty acids to enrich the energy concentration of dairy cows ration is gaining acceptance with some limitations. Results of fat inclusion in lactating cows ration are inconsistent. Many researchers cleared the disadvantages of fat inclusion on dry matter intake, digestibility of protein and fiber inparticular and the milk protein content (Devendra and Lewis,1974; Yang *et al.*,1978; Schauff *et al.*,1992 and Grummer *et al.*,1993). Eventhough preponderance of data demonstrated profits of adding fat on milk yield. fat content of milk and body condition (Chilliard . 1993; Harrison *et al.*, 1995 and Drackley *et al.*,1998).

In this study AFRC, 1993 requirements were used as a base line as they give allowances for feeding level, size and type of animal, changes in fetus requirements according to days of pregnancy, yield of milk and it's constituents as well as body weight changes of the cow. The objective of this study is to evaluate the effect of feeding 110 and 115 % of the AFRC metabolizable energy (ME) requirements on the productive performance of our Friesian cows.

MATERIALS AND METHODS

Experimental design and diets

Six dairy Friesian cows in the second and fourth lactation season averaged 459.5 ± 13.7 kg body weight were used in this study after the peak of their lactation curve (12 weeks post calving). Switch back design (Lucas,1956) was adopted in this work. Cows were fed according to AFRC (1993) standards. A concentrate mixture was formulated from yellow corn 50%. wheat bran 40 %, soybean meal 7 %, calcium carbonate 2 %, commercial salt of sodium chloride 1 %. This mixture provide 2.53 Mcal. ME / kg DM and 15.91 % crude protein (CP). Commercial fat source (poultry grease) was added to the concentrate mixture just before feeding in amounts that represent 0, 10 and 15 % of the ME requirements for each cow, accordingly three treatments were postulated. Treatment T1, the control treatment, T2 containing 110 % of AFRC ME requirements and T3 that contains 115 % of AFRC ME requirements. All diets were isonitrogenous and provide 100 g metabolisable protein (MP/ kg DM). Chopped wheat straw was offered *ad lib.* as a roughage source. The amount consumed was calculated for each cow. Miniralised salts licking blocks were available along the experiment. cows were injected with their requirements of vitamins A, D_3 &E every two weeks.

Feeding and management

Cows were kept inside window stables and allowed to exercise in the yard from 8 p.m. to 12 p.m. The feed for each cow was weighed separately and fat was handly mixed with the individual amount of concentrate at each feeding time. Cows were milked twice daily at 7 a.m. and 5 p.m.. While they were fed at 9 a.m. and 6 p.m. Each cow was fed the experimental diet for a month . Cows were adopted gradually to the diet through the first 10 days , while samples were collected through the last week . Cows were weighed at the beginning and at the end of each feeding period before feeding . The mean dry matter intake (DMI) in the last week of each feeding period was considered in calculation of digestibility coefficients and feeding value.

The treatments (T1, T2 and T3) feeding pattern was as follows:

Periods	Cows					
	1	2	3	4	5	6
1	T1	T2	T3	T1	T2	T3
2	T2	T3	T1	T3	T1	T2
3	T1	T2	T3	T1	T2	T3

Sampling and laboratory analysis

A fixed portion samples of diets were collected daily in the last week and composite samples were formed. dried at 70 °C for 48 h (a fixed weight), ground and kept in closely tied jars for laboratory analysis . Fecal grab samples were collected from each cow in each feeding period at 7 a.m. and 2 p.m. on days 24 and 27. A composite fecal samples for each cow on each experimental diet were formed , dried , ground , and stored in closely tied jars for laboratory analysis. Feed and fecal samples were analysed for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash according to A.O.A.C (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined as Goring and Van Soest (1970). The digestibility of DM, OM, CP, EE, CF, NDF, ADF, hemicellulose and gross energy (GE)were determined using acid insoluble ash as an internal marker (Van Keulen and Young , 1977). Milk yield was recorded daily for each cow and composite milk samples from morning and afternoon milking were collected on days 24 and 27 of each period and then analysed individually for total solids, total nitrogen and ash according to A.O.A.C (1990). Milk fat was determined using Gerber units.

Statistical analysis:

The statistical analysis was done according to Lucas (1956). Duncan's multiple range test were used to determine the significance of differences among treatment means using SAS (1990) program.

RESULTS

The proximate analysis of concentrate mixture (CM,T1), CM plus 10 % fat (T2), CM plus 15 % fat (T3) and wheat straw (W.S.) are presented in Table 1. Supplementation of poultry grease to the concentrate mixture increased the ether extract (EE) content 1.99 (T2) and 2.48 (T3) times it's concentration in the control CM (T1). Supplementation of fat (10 and 15%) increased the whole diet EE concentration 1.77 and 2.16 times it's concentration in the control CM (T1). The concentration of other nutrients were almost similar despite the slight increase in OM content due to fat supplementation (Table 1). Dry matter intake of concentrate mixture and of the whole diet are recorded in Table 2. Fat supplementation significantly ($P<0.05$) increased the total DMI (TDMI) being 13.41, 14.72 and 15.17 kg/d for T1, T2 and T3 respectively. This increase is observed in both CM and W.S. Concentrate : roughage ratio were nearly similar 3:1, 2.89:1 and 2.93:1 for T1, T2 and T3 respectively. Digestibility coefficients and feeding value data are shown in Table 3. Significant improvement was found in DM, OM, CP, EE and CF digestibility due to Fat supplementation. Also there was a significant ($P<0.05$) achievement in nutrients digestibility coefficients as the level of supplemental fat was increased from 10 to 15% (T2 compared with T3). The highest digestibilities were noticed when T3 was fed . Total digestible nutrients (TDN) value was significantly improved from 670 to 727 and 775 g/kg DM when T1, T2 and T3 were fed respectively. Digestibility of energy and cell wall constituents (NDF, ADF and hemicellulose) were improved as well due to fat supplementation. The highest values were recorded for T3, while the lowest values were recorded for T1. The increment was 5.66 % considering energy digestibility when T1 was compared with T3. Nutritive ratio was also changed from 1:5.96 to 1:6.5 and 1:6.77 for T1, T2 and T3 respectively.

Table 1. Proximate analysis and constituents of concentrate mixture, wheat straw and diets consumed (g/kg dry matter) by dairy Friesian cows

Nutrients (g/Kg)	DM	On dry matter basis									
Feeds		OM	CP	EE	CF	NDF	ADF	Hemi-cellulose	NFE	Ash	GE (Mcal)/Kg
Concentrate M. (T1)	901	932	159	39.3	43.4	303	64.1	239	690	68.0	4.47
Concentrate M.+10 % fat (T2)	903	937	160	78.1	41.1	301	63.8	237	658	63.4	4.71
Concentrate M.+15 % fat (T3)	905	942	159	97.4	40.8	295	58.8	236	645	58.0	4.87
Wheat straw (W.S.)	928	874	36.4	30.8	318	779	512	267	489	126	3.97
Nutrient constituents of the diets consumed (concentrate mixture + wheat straw).											
Control, C (T1)	908	918	128	37.2	112	422	176	246	640	82.4	4.37
C+10% fat (T2)	901	921	128	66.0	112	424	179	245	615	79.4	4.54
C+15% fat (T3)	911	925	128	80.5	111	418	174	244	605	75.2	4.66

Table 2. Dry matter intake (DMI) of dairy Friesian cows fed the experimental diets (kg/d).

Items	Treatments			Mean SE	Sign.
	T1	T2	T3		
Concentrate intake (kg / d)	10.1	10.6	10.7	------	------
Fat supplement (kg / d)	------	0.375	0.597	------	------
Concentrate plus fat (kg / d)	10.1^b	10.9^a	11.3^a	0.224	**
Wheat straw (kg / d)	3.35	3.78	3.86	0.096	NS
Total DM intake (kg / d)	13.4^b	14.7^a	15.2^a	0.31	*
Concentrate:Roughage ratio	3 : 1	2.89 : 1	2.93 : 1	------	------

a, b Means in the same raw having different superscripts are significantly differed (* $P<0.05$, ** $P<0.01$). NS = Not significant.

Data of milk yield and milk constituents are presented in Table 4. Significant increase ($P<0.05$) was observed in all parameters due to fat supplementation except lactose concentration, however, lactose yield (kg/d) was significantly increased ($P<0.05$) in response to fat supplementation that improved FCM yield by 42.7 and 13.16 % according to the level of fat supplementation. Protein yield was greater by 38.09 and 23.81 % comparing T3 and T2 with T1 (the control ration). Figures obtained for T3 were greater than those for T2, however the differences were not significant except for fat yield, where the difference was significant (0.70 and 0.61 kg/d).

DISCUSSION

The improvement in nutrients digestibility and nutritive value of fat containing rations may be partly due to altering the activity or individuals of microbial population inhabiting the reticulo-rumen compartment and / or slightly shifting the site of digestion to the hind gut (Ikwuegbu and Sutton,1982; Palmquist,1984; and Paul *et al.*,1996). It is well documented that VFA's, methane and carbon dioxide are the end products of carbohydrate fermentation in the reticulo-rumen, while simple sugars, mostly glucose are the end products of carbohydrate digestion in the intestine.

The experimental diets contain more than 600 g/kg DM soluble carbohydrates, therefore, slight change of carbohydrate digestion end products from VFA's to glucose is expected leading to more efficient utilization of dietary energy (McDonald *et al.*,1994). Moreover, Van Der Honing *et al.* (1981) reported significant increase in efficiency of gross energy utilization (10.1 %) and of metabolisable energy (4.75 %) when 7 % tallow was added to the concentrate. Chan *et al.* (1997) indicated that the flow of OM to the duodenum was increased by added fat. A significant reduction in methane production was reported when long chain unsaturated fatty acids were added to the diet (Czerkawski,1966). All these reviewers agree with the improvement observed in utilization of fat containing diets (T2 and T3 in comparison with T1). In this work using poultry grease in amounts mentioned above did not exert any adverse effect on nutrients digestion, but on the contrary, CF digestibility was enhanced by 10.5 and

24.0 % when T2 or T3 were fed. The same trend was observed for NDF and ADF which is in agreement with that found by Palmquist and Conrad (1980); Zinn (1989) and Paul (1994). Absence of negative effect of supplemented fat on digestibility could be due to compensatory effects of hind gut fermentation and presence of calcium. The specific quantitative requirement of calcium in high fat diet has not been determined; 0.9-1.0 % of the diet dry matter has been suggested (palmquist,1984). The experimental diets fed in this study contain 0.8% calcium as calcium carbonate salt beside calcium consumed from the mineralized salt blocks and the feed ingredient. In accordance with improvement achieved in digestibility, the indigestible portion became less and the cows ate more to keep the constant fill of the alimentary tract. This may explain the increment attained in TDMI (kg/d) 9.77 and 13.12 % when T2 and T3 were fed, respectively. Such result is in agreement with that of Lacount *et al.* (1995). They stated that long-term fat supplementation tended to increase DMI.

Table 3. Digestibility coefficients of feed nutrients and the feeding value of the experimental diets fed to dairy cows (g/kg).

Treatment	Treatments				
Nutrient	Control (T1)	Control+10% fat (T2)	Control+15%fat (T3)	Mean SE	Significance
DM	676^c	689^b	713^a	3.75	**
OM	696^c	717^b	741^a	4.45	**
CP	749^c	758^b	779^a	4.70	**
EE	665^c	818^b	887^a	23.1	**
CF	441^c	487^b	546^a	11.2	**
NFE	733^b	739^a	749^a	1.73	*
TDN	670^c	727^b	775^a	10.4	**
Energy(kcal/Mkal)	653	678	690	6.11	NS
NDF	549	577	590	10.7	NS
ADF	435	470	492	20.3	NS
Hemicellulose	637	657	679	8.1	NS
Nutritive ratio[1]	1 : 5.96	1 : 6.5	1 : 6.77	-----	----

[1] Nutritive ratio = Digestible protein / TDN-Digestible protein a, b, c Means in the same raw having different superscripts are significantly differed (*P<0.05, **P<0.01). NS =Not significant.

Table 4. Milk yield and it's composition of dairy Friesian cows fed the experimental diets

Items	Treatments			Mean SE	Significance
	Control (T1)	Control +10%fat (T2)	Control +15%fat (T3)		
Milk yield (kg/d)	12.8^b	15.1^a	16.4^a	0.54	*
4 % FCM (kg/d)	12^b	15.1^a	17.1^a	0.66	*
FCM/TDMI	0.89^b	1.03^a	1.11^a	0.03	*
SCM[1]	13.6^b	17.0^a	19.2^a	0.73	*
SCM/TDMI	1.01^b	1.15^a	1.25^a	0.03	*
Milk composition (g/kg)					
Fat	36.0^b	40.2^a	42.8^a	0.8	*
Protein	32.7^b	34.7^a	35.3^a	0.4	*
Lactose	44.8	45.7	45.1	0.8	NS
Total solids	121^b	129^a	130^a	0.8	*
Milk constituents (kg/d)					
Fat	0.46^c	0.61^b	0.70^a	0.03	*
Protein	0.42^b	0.52^a	0.58^a	0.02	*
Lactose	0.57^b	0.69^a	0.74^a	0.03	*

[1]SCM=solid corrected milk=112.82Xmilk fat yield +7.13Xmilk protein yield+0.323Xmilk production (Tyrrell and Reid,1965)

a, b, c Means in the same raw having different superscripts are significantly differed (*P<0.05).

NS =Not significant.

The improvement gained in milk yield, yield and concentrations of milk constituents could be understood as a reflex of enhancement observed in digestibility of feed nutrients, feeding value, dietary energy density and TDMI due to fat supplementation. Moreover supplementation of fat with it's high metabolisability may balance the nutrients required for milk constituents synthesis leading to better efficiency of nutrients utilisation. Palmquist (1984) indicated that fat may be used to increase milk, milk fat and efficiency of production. Drackley *et al.* (1998) found that the intake of net energy for lactation and energy balance were greater during weeks 4 - 25 of calving for cows fed diets supplemented with fat. These findings coincide with results reported herein as the experiment was done after 12 weeks from calving. They reported an increase of 2.2 kg milk/day during weeks 4 - 25 in this study we gained 2.26 and 3.58 kg milk / day according to the level of fat supplementation. This difference in response may be due to breed of cow, their production level, the amount and source of fat applied and the ration composition. Supplementation of fat raised the level of fatty acids in plasma, giving chance of direct transfer of these fatty acids to mammary gland tissues and contribute in milk fat composition. This may explain the increment realised in milk fat concentrations (g/kg), yield (kg/d) and the yield of fat corrected milk, when T2 and T3 were fed in comparison with T1. These results are in agreement with that of Kronfeld (1982) and Harrison *et al.* (1995). The improvement in protein concentrations with a concomitant increment in milk yield increased the protein yield (kg/d) when fat supplemented diets were fed. This improvement is an expression of N containing compounds supply and availability for milk protein synthesis and transfer of plasma N to milk. In this study soybean meal was the portion concentrate source used in diet formulation. Chan *et al.* (1997) found that yields of milk, milk protein and SNF were increased by added fat and high quality protein. They considered soybean meal as a component of high quality protein mixture due to it's high content of lysine. A positive response of high dietary lysine on yields of milk and milk protein was recorded (Chen *et al.*,1993). Addition of fat may exert it's effect through balancing the nutrients required for synthesis of milk protein with better efficiency. The increase in lactose yield (kg/d) when cows fed the fat containing diets is in fact a result of the increment attained in milk yield, while the changes in lactose concentration were inconsistent with the level of fat supplementation. This result is parallel to that reported by Palmquist, (1984) and Chan *et al.*(1997).

CONCLUSION

Positive responses were gained when the gross energy density of our dairy Friesian cows rations raised up to 4.66 Mcal / kg DM using poultry grease. The energy requirements of these cows need to be recalculated considering nutrient Utilization and milk production parameters.

REFERENCES

AFRC. 1993. Technical committee on responses to nutrients. Energy and protein requirements of ruminants. CAB International, Wallingford. Oxon, OX 10 8DE, U.K.

A.O.A.C., 1990. Official Methods of Analysis (15*th* ed.) Association of Official Analytical Chemists. Arlington, U.S.A.

Chan, S.C.; J. T. Huber; C. B. Theurer ; Z. Wu ; K. H. Chen ; and J. M. Simas , 1997 . Effects of supplemental fat and protein source on ruminal fermentation and nutrient flow to the duodenum in dairy cows . J. Dairy Sci., 80: 152-159

Chen, K. H.: J. T. Huber; C. B. Theurer; D. V. Armstrong; R. C. Wanderley; J. M. Simas; S. C. Chan, and J. L. Sullivan. 1993.

Chilliard , Y.; 1993. Dietary fat and adipose tissue metabolism in ruminants, pigs and rodents : a review . J. Dairy Sci., 76:3897-3931.

Czerkawski , J. W. ; K. L. Blaxter ; and F. W. Wainman , 1966. The effect of linseed oil fatty acids incorporated in the diet on the metabolism of sheep . British J. of Nutr. 20:485-494 .

Devendra . C. and D. Lewis . 1974. The interaction between dietary lipids and fiber in the sheep. IV. Duodenal studies . Malaysian agricultural Research 3 , 228-241. After Palmquist . D. (1984) Fats in Animal feeding systems , pp. 357-382 . Edit. J. Wiseman . Butterworths .

Drackley, J. K. ; D. W. Lacount ; J. P. Elliott ; T. H. Klusmeyer ; T. R. Overton ; J. H. Clark, and S. A. Blum, 1998 . Supplemental fat and nicotinic acid for Holstein cows during an entire lactation . J. Dairy Sci., 81:201-214 .

Goring , H. K. and P. J. Van Soest , 1970 . Forage fiber analysis . U.S.D.A. Agriculture hand book, no 379.

Grummer, R. R.; M. L., Luck and J. A., Barmore, 1993. Rumen fermentation and lactation performance of cows fed roasted soybeans and tallow. J. Dairy Sci. 76:2674-2681.

Harrison, J. H.; R. L., Kincaid ; J. P., McNamara ; S., Wattner ; K. A., Loney ; R. E., Riley and J. D., Cronrath. 1995. Effect of Whole cotton seeds and calcium salts of long-chain fatty acids on performance of lactating dairy cows . J. Dairy Sci. 78:181-193 .

Ikwuegbu, O. A. and J. D. Sutton, 1982. The effect of varying the amount of linseed oil supplementation on rumen metabolism in sheep. Br. J. Nutr., 48: 365-375.

Kronfeld, D. S. ,1982 . Major metabolic determinations of milk volume, mammary efficiency. and spontaneous ketosis in dairy cows. J. Dairy Sci. 65: 2204-2212 .

Lacount, D. W.; J. K. Drackley; T. M. Cicela, and J. H. Clark,1995. High oil corn as silage or grain for dairy cows during an entire lactation. J. Dairy Sci. 78: 1745-1754.

Lucas, H. L. 1956 . Switch back trials for more than two treatments . J. Dairy Sci., 39:146-154 .

McDonald, P.; R. A. Edwards and J. F. D. Greenhalgh. 1994. Animal Nutrition. Evaluation of foods. (B) Energy content of foods and the partition of food energy within the animal PP 217-244. Longman Scientific & Technical. Longman Group UK Ltd.

Palmquist, D. L. 1984. Use of fats in diets for lactating dairy cows. PP 357-381. Fats in animal nutrition, J. Wiseman, editor, Butterworths, London.

Palmquist, D. L. and H. R., conrad, 1980 . High fat rations for dairy cows . Tallow and hydrolyzed blended fat at two intakes . J. Dairy Sci., 63:391-395 .

Paul, B. N., 1994 . Nutrient utilisation in ruminants as affected by nature and level of dietary lipids . Ph. D. thesis. National Dairy Research Institute, Karnal, India. C. F. Paul *et al.*, 1996 .

Paul, B. N.; A., Srivastava and P. K. Mukhopadhyay, 1996. Nutrient digestibility as influenced by nature and level of dietary lipids . A review . Indian J. Dairy Sci., 49:537-545.

SAS., 1990. SAS user's guide : Statistics, Version 5 ED. SAS Institute, INC., Cary, NC., USA.

Schauff, D. J. ; J. P., Elliott ; J. H. Clark, and J. K. Drackley, 1992. Effects of feeding lactation dairy cows diets containing whole soybeans and tallow . J. Dairy Sci., 75: 1923-1935.

Tyrrell, H. F.and J. T., Reid., 1965. Prediction of the energy value of cow's milk. J. Dairy Sci. 48: 1215-1223.

Van Der Honing, Y.; B. J., Wieman; A., Steg and B., Van Donselaar, 1981. The effect of fat supplementation of concentrates on digestion and utilization of energy by productive dairy cows . Netherlands J. of Agric. Sci., 29:79-92. CF. Palmquist, D. 1984 .

Van Keulen , J. and B. A. Young, 1977. Evaluation of Acid -Insoluble ash as a natural marker in ruminant digestibility studies . J. Anim. Sci., 44: 282-287.

Yang, Y. T.; R. L. Baldwin and J. Russell., 1978. Effects of long supplementation with lipids on lactating dairy cows. J. Dairy Sci., 61: 180-188.

Zinn, R. A., 1989. Influence of level and source of dietary fat on it's comparative feeding value in finishing diets for feed lot steers metabolism. J. Anim. Sci., 67:1038-1049.