ENHANCEMENT OF THE NUTRITIVE VALUE OF FULL-FAT CANOLA SEED FOR RUMINANTS.

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ABSTRACT

Full-fat canola seed (FFCS) is an excellent source of energy (40% fat) and crude protein (CP) (20%). Therefore, its inclusion in the diet of high producing ruminants, where intake is a factor limiting performance, could result in an economic response in milk production. Two experiments were conducted to evaluate utilization of FFCS by ruminants. In experiment 1, fifteen lactating cows were allotted to five dietary treatments on the basis of milk yield and lactation number. The experimental design was a Latin square with 28 day periods. Diets were isonitrogenous and contained on a dry matter (DM) basis approximately 50% concentrate, 35% alfalfa hay and 15% beet pulp. The control concentrate (diet 1) contained 15% canola meal, 30% barley and 5% molasses, minerals and vitamins. In diets 2, 3, and 4, respectively, 5.9, 11.9, and 17.8% ground FFCS was included in the concentrate mix in replacement of canola meal and barley. In Diet 5, 5% canola oil was added in replacement of barley. Compared to the control diet (28.0 kg/d), milk yield was significantly lower for cows fed diet 3 (25.9 kg/d) and diet 4 (24.1 kg/d). The depression in milk yield was attributed to the negative effect of high fat intake on rumen microbes, which resulted in digestive upsets and a high incidence of diarrhea in cows fed diets 4, and to a lesser extent diet 3. In experiment 2, Jet-Sploding was evaluated as a processing method to decrease the extent of microbial degradation of canola seed, hence not only alleviate the negative impact on rumen microbes, but also increase the supply of rumen escape protein and fat. The in situ nylon bag technique was used to evaluate the efficacy of Jet-Sploding. Duplicate samples of ground FFCS and Jet-Sploded FFCS were incubated in the rumen of two cows for 2, 4, 8, 12, and 24 h. Upon removal from the rumen, bags were washed, dried in a forced air oven, and digested intact for Kjeldahl and nitrogen analysis. CP disappearance (%) of ground and Jet-Sploded FFCS respectively, at 0, 2, 4, 8, 12, and 24 h were 42.0, 6.2; 67.1, 19.4; 81.6, 20.8; 89.6, 31.6; 91.8, 45.2; 93.6 and 80.4. Corresponding values for DM were 39.9, 16.8; 63.0, 21.7; 79.9, 23.7; 85.3, 30.5; 88.4, 42.6; 91.4 and 76.6. Jet-Sploding significantly enhanced the nutritive value of FFCS for ruminants by reducing the extent of microbial degradation in the rumen, thereby allowing higher levels of inclusion of FFCS in the diet. This offers economic gains for both canola producers as well as dairy producers.

INTRODUCTION

The use of full-fat oilseeds as a high energy supplement for lactating dairy cows, is becoming increasingly popular among producers striving to meet the energy needs associated with cows of high genetic merit. Research reports on the use of full-fat oilseeds, including cottonseed (Anderson et al., 1979; Smith et al, 1981; De Peters et al., 1985), sunflower seed (McGuffey and Shingoethe, 1982; Rafalowski and Park, 1982) and soybeans (Larson and Shultz, 1970; Perry and MacLeod, 1968; Ruegsegger and Shultz, 1985) have generally been favourable to their inclusion in the diet of lactating dairy cattle. Full-fat canola seed (FFCS) has a similar fat (approximately 40%) and protein (approximately 20%) content to sunflower seed (McGuffey and Schingoeth, 198?). While cottonseed has a similar protein content to FFCS its fat content is approximately half of that observed in FFCS. The high fat content of FFCS tends to limit the level at which it can be included in the diet without causing deleterious effects on microbial digestion in the rumen. Formaldehyde treatment of FFCS has been used successfully to increase the extent of rumen escape. In this report the use of Jet-Sploding to increase rumen escape of FFCS has been evaluated. Jet-Sploding uses a high temperature (315°C) for a short period of time and utilizes the moisture within the seed in contrast to extrusion with steam.

The objectives of the studies reported herein were: (1) to determine the efficacy of FFCS as an energy and protein supplement for lactating dairy cows, and (2) to evaluate the effectiveness of the Jet-Sploding process in increasing the extent of rumen escape of dry matter (DM) and crude protein (CP) in FFCS.

MATERIALS AND METHODS

EXPERIMENT 1

Fifteen Holstein cows were allotted to five dietary treatments, Table 1. The experimental design was a Latin square with each period being 28 days for a total experimental duration of 20 weeks. The control treatment contained canola meal (CM) as the sole source of supplemental protein. In concentrates 2, 3 and 4 respectively, 5.9, 11.9 and 17.8% FFCS was included at the expense of CM and barley. The FFCS used in this study was finely ground prior to incorporation into the test diets. Diet 5 was similar to diet 1 except that 5% canola oil was added at the expense of barley. The concentrate mixture was fed

Table 1. Composition and chemical analysis of concentrate diets fed in Experiment 1.

Concentrate Type Diet No.:	Control 1	6% FFCS[1] 2	12% FFCS 3	18% FFCS 4	5% Canola Oil 5
Ingredient, %					
Barley	48.3	44.6	41.0	37.4	40.0
Oats	25.0	25.0	25.0	25.0	26.4
Wheat	5.0	5.0	5.0	5.0	5.0
Canola meal	15.0	12.7	10.4	8.1	16.9
Molasses	3.0	3.0	3.0	3.0	3.0
Whole canola seed	0.0	5.9	11.9	17.8	0.0
Canola oil	0.0	0.0	0.0	0.0	5.0
Dicalcium phosphate	1.2	1.2	1.2	1.2	1.2
Calcium carbonate	1.4	1.4	1.4	1.4	1.4
Vitamin-mineral premix[2]	1.0	1.0	1.0	1.0	1.0
Chemical analysis, % of Dry Matter					
Protein, %	15.8	15.8	15.6	16.0	15.6
Total lipid, %	3.56	6.07	8.34	11.05	8.81
Gross energy, MJ/kg	18.08	18.72	19.35	20.12	19.64

1 FFCS = Full-Fat Canola Seed which was ground prior to incorporation into diet.

2 The premix provided the following per kg of concentrate: 40 mg zinc; 16 mg iron; 12 mg manganese; 3.3 mg copper; 0.7 mg iodine; 0.4 mg cobalt; 5000 IU vitamin A; 8325 IU vitamin D; 5 IU vitamin E to the concentrate diet.

according to milk production or to a maximum of 14 kg/day. In addition to the above concentrate mixture all animals were offered 7 kg chopped hay and 3 kg beet pulp daily (as-fed basis). Cows were weighed on two consecutive days at the start of the study and on the final two days of each period. Pooled milk samples for the final two days of each experimental period were used to determine milk composition. Milk fatty acid concentrations were determined by quantitating methyl esters of the fatty acids on a gas chromatograph (Cadden et al., 1984).

EXPERIMENT 2

One gram samples of FFCS, Jet-Sploded FFCS (J-FFCS) and Protec® (a product based on formaldehyde treatment of CM and FFCS) were weighed into small 3.5 cm x 5.5 cm heat sealed nylon bags and incubated in the rumen of two lactating Holstein cows which were cannulated in both the rumen and duodenum. A total of 36 bags, 18 bags per cow, were prepared for each protein source. Two bags per cow were washed to obtain estimates of soluble DM and CP (t=o). Ten bags per cow, per feedstuff, were suspended in the rumen within a polyester mesh bag (De Boer et al., 1987a) for 2, 4, 8, 12 and 24 h. Another six bags per cow (duplicate samples for 0, 8, and 12 h rumen incubations) were inserted into the duodenum, through the duodenal cannulae, and recovered from feces (De Boer et al, 1987b) to estimate intestinal digestibility of DM and CP. After rumen incubation and/or intestinal passage, bags were briefly washed under cold tap water to remove surface debris and machine washed (De Boer et al., 1987a).

Washed nylon bags were dried at 60°C for 24 h in a forced air oven. Bags plus contents were subjected to Kjeldahl nitrogen (N) analysis. Empty bags were analyzed for N and blank values subtracted from total N prior to calculation of CP disappearance. Percent disappearance of DM and CP at each incubation time was calculated from the proportion remaining in the bag after incubation in rumen, or transit through the intestine.

RESULTS AND DISCUSSION

EXPERIMENT 1

Cows fed the highest level (18%) of FFCS had significantly lower milk production (Table 2) than those fed the control or 6% FFCS diets. Total milk fat yield was significantly lower for cows fed diets containing FFCS or canola oil than those fed the control diet. Cows fed 6% FFCS had similar milk yield and milk protein content to those fed the control diet. Overall milk production, on all treatments, was lower than predicted on the basis of previous lactation performance. This depression may be due in part to a carryover effect from one experimental period to the next. The design of this study was such that the changeover from one diet to the next was abrupt. Cows receiving 18% FFCS, and to a lesser extent those fed diets containing 12% FFCS, frequently suffered from diarrhea. This was particularly evident when animals were switched from control, or 6% FFCS diets, to 18% FFCS diet. Cows fed 18% FFCS tended to suffer a marked depression in milk yield which was carried over to the next experimental period. Despite thse problems, it was apparent that cows adapted to the presence of FFCS in the diet over a period of 2-3 weeks.

Mean lipid intake from the concentrate for cows fed diets 1 to 5 respectively were 0.40, 0.71, 0.92, 1.22 and 0.96 kg/day. The inclusion of FFCS resulted in significant changes in 9 of the 10 milk fatty acids measured. Cows fed FFCS had significantly lower content of short chain fatty acids while the level of long chain fatty acids in milk increased (Table 3). The response to further increments of FFCS, beyond 6%, was less pronounced; the concentrations of most milk fatty acids were not significantly different for cows fed concentrates containing 6, 12 or 18% FFCS. The responses to feeding 5% canola oil were similar to those obtained when cows were fed a similar amount of lipid in the form of FFCS. These results suggest that feeding lipid in the form of FFCS does not markedly reduce the extent of degradation or hydrogenation by rumen microbes.

EXPERIMENT 2

Dry matter and CP disappearance data are in Table 4. Jet-Sploding of FFCS significantly reduced ruminal DM and CP disappearance. Disappearance data for J-FFCS were similar to that observed for Protec®. Jet-Sploding effectively reduced the extent of rumen degradation of FFCS, thus potentially increasing

Table 2. Influence of feeding full-fat canola seed (FFCS) on liveweight change, feed intake, milk yield and milk composition (Experiment 1).

Concentrate Type Diet no.:	Control 1	6% FFCS 2	12% FFCS 3	18% FFCS 4	5% Canola Oil 5	SE[1]
Liveweight change, kg/d	0.61ab*	0.37bc	-0.01c	0.20ac	0.50ab	0.15
Intake, kg/d (as fed)						
Concentrate	11.25a*	11.64b	11.20a	10.93c	10.81c	0.06
Hay	6.46a*	6.20ad	5.50b	5.82c	6.00cd	0.08
Beet pulp	2.92a**	2.85bc	2.81b	2.84c	2.91a	0.01
Milk yield and composition						
Milk yield, kg/d	28.00a*	27.96a	25.89ab	24.14b	25.08bc	0.82
Fat corrected milk, kg/d	19.64a*	18.08b	17.01bc	15.90c	16.83c	0.40
Fat, %	2.05	1.88	1.97	1.90	1.83	0.06
Fat, kg/d	0.56a**	0.49b	0.48b	0.45b	0.46b	0.01
Protein, %	3.09	3.17	3.19	3.20	3.26	0.02
Protein, kg/d	0.86a*	0.85a	0.78b	0.76b	0.79b	0.02
Lactose, %	4.83	4.77	4.78	4.78	4.70	0.03
Lactose, kg/d	1.36a*	1.29a	1.18b	1.10b	1.15b	0.04

a-d Means in the same row with the same letters do not differ (*P<0.05; **P<0.01).

Table 3. Influence of feeding full-fat canola seed (FFCS) on the fatty acid composition of milk (Experiment 1).

Fatty acid, %	Control	6% FFCS	12% FFCS	18% FFCS	5% Canola Oil	SEM[1]
4:0	2.43	1.90	1.89	.88	1.72	0.18
6:0	1.~6a*	1.18b	1.21b	1.08b	1.10b	0.11
8:0	1.03a**	0.71b	0.69b	0.66b	0.66b	0.05
10:0	2.68a**	1.82b	1.77b	1.79b	1.76b	0.10
12:0	3.48a**	2.63b	2.51b	2.69b	2.56b	0.19
14:0	12.33a**	10.58b	10.07b	10.80b	10.36b	0.26
16:0	27.94a*	25.01b	24.30b	25.67b	25.22b	0.72
18:0	6.03a**	7.27b	7.91b	7.03b	7.17b	0.22
trans - 18:1	6.57a**	8.63b	9.07b	9.23b	9.90b	0.55
cis - 18:1	18.68a**	22.58ab	23.18b	21.98ab	22.39ab	0.86

[1] SEM - standard error of the mean

a-c Means in the same row with the same letters do not differ (*P<0.05; **P<0.01).

the amount of dietary protein available for digestion in the small intestine. Similar effects of increased heat on degradation of DM and CP in the rumen have been reported (Lindberg, 1984; Mir et al., 1984). Total tract disappearance of DM for the Jet-Sploded product increased with time of rumen exposure. This effect was not apparent for CP. After 12 h of rumen exposure total tract disappearance of DM and CP were similar for FFCS, J-FFCS and Protec®. The results suggest that Jet-Sploding has potential for decreasing ruminal degradation without dramatically decreasing intestinal digestibility of DM and CP.

Table 4. Dry matter (DM) and crude protein (CP) disappearance (%) from nylon bags (a) incubated in the rumen and (b) after total tract (rumen (12 h) plus intestine incubations (Experiment 2)).

Rumen Incubation time (h)	FFCS		J-FFCS		Protec®[1]	
	DM	CP	DM	CP	DM	CP
0	39.9	42.0	16.8	6.2	30.2	23.1
2	63.0	67.1	21.7	19.4	29.6	22.2
4	79.9	81.6	23.7	20.8	31.8	24.0
8	85.3	89.6	30.5	31.6	41.0	31.7
12	88.4	91.8	42.6	45.2	48.4	39.5
24	91.4	93.6	76.6	80.4	61.4	49.7
SEM[2]	1.18	1.11	0.24	0.40	0.70	0.79
Total Tract Disappearance						
12 h	91.7	93.1	79.8	87.9	85.3	91.1

[1] Protec®, a protected lipid supplement based on formaldehyde treated canola meal and FFCS.

[2] SEM = Standard Error of the Mean.

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