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Effect of Dietary Soybeans Extruded at Different Temperatures on Dairy Cow Milk Composition

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INTRODUCTION

Full-fat soybeans(FFSB) contain 40% of crude protein and 17 to 20% fat and are of interest as a source of protein and energy in the ration of high yielding dairy cows especially during early lactation. FFSB have been investigated mainly as a source of protein, and various heat treatment have been applied to increase proportions of undegradable protein in the rumen when FFSB are fed to lactating cows[1~6)]. However, little attention has been given to influence of heat-treated FFSB on the fatty acid(FA) composition of milk fat.

A knowledge of the level of trans-FA in milk would appear to be important because they are suspected to interfere with normal milk fat synthesis within the mammary gland of dairy cows[7)]. Some advantages are gained by the increase of polyunsaturated fatty acid(PUFA) content in milk fat. Therefore, a simple treatment of FFSB to achieve these advantages would appear desirable.

One of the mechanisms involved to explain this phenomenon was that the heating process produced chemical changes to protein that might have encapsulated or tied up FA, making them less available for digestion[(8)]. Consequently, heat treatment of FFSB might favor ruminal bypass of the lipid fraction.

The objectives of this study was to determine whether extrusion of FFSB, as well as extrusion temperature, affected the FA composition of milk fat.

MATERIALS AND METHODS

1. Preparation of Samples

Ten tones of whole soybeans were purchases locally in one lot and ground through a 6.35-mm screen. One part(2.5 tonnes) was not treated and was identified as raw soybeans(RS). The other part was divided into three equal portions, and each portion was dry-extruded in a commercial extruder. During the extrusion process, soybeans reached a maximum measured temperature of 120℃(E120), 130℃(E130), or 140℃(E140).

2. Cows, Treatments, and Sampling

At calving, 24 multiparous Holstein cows, 4 of which were ruminally fistulated, were fed a diet of soybean meal, cracked corn, and corn and grass silages as the basal diet. After being fed this diet for 35±10d(X±SD), the 20 unfistulated cows were divided into five blocks of 4 cows each based on milk yield during the previous lactation. One block contained the 4 ruminally fistulated cows, regardless of their milk yield during the previous lactation.

Sampling periods were the last wk of the preliminary phase(wk-0) and wk-4 and 8 of the experimental phase. During of each these period, samples of the total mixed diet were examined, samples of blood and milk were analyzed, and cow were weighed. Feed intake was measured each day during each of these sampling periods and corrected for DM based on samples of the total mixed diet taken twice weekly. Milk was sampled in proportion to milk yield for consecutive milkings at 07:00h and 17:00h and then freeze-dried immediately. Blood was taken from jugular vein once at each sampling period between 10:00h and 11:00h.

3. Chemical Analysis

Samples analyzed for neutral detergent fiber(NDF) and acid detergent fiber(ADF) according to the procedure outlined by Goering and Van Soest(9), for Ca and Mg by atomic absorption after dry-ashing(10), and for P by the colorimetric method(11). Samples were analyzed for crude protein(CP) by Kjeldahl procedure(10), and for ether extract using anhydrous diethyl ether(12). Fatty acid profile was determined following the GLC technique.

RESULTS AND DISCUSSION

1. DMI, BW and Milk Yield

The Chemical composition of the diets is shown in Table 1.

The dry matter intake(DMI) of cows fed RS or extruded soybeans(ES) was not different, and dietary treatment had no effect on the body weight(BW) of cows at wk 4 and 8 of the experimental period. In general, the extrusion of FFSB apparently has no effect on the BW of milking cows.

Table 1. Chemical composition of total mixed diets (%, DM basis)

Item	Treatment[1)]				
	Basal	RS	E120	E130	E140
NE_l[2)], Mcal/kg of DM	1.7	1.7	1.7	1.7	1.7
CP	15.9	15.9	15.9	15.9	15.9
Ether extract	2.9	6.0	6.2	5.8	6.1
Fatty acids					
$C_{14:0}$	0.4	0.2	0.2	0.2	0.2
$C_{16:0}$	11.2	11.6	10.8	10.9	10.6
Δ-9-*cis*-$C_{16:1}$	0.4	0.2	0.2	0.2	0.2
$C_{18:0}$	2.1	3.7	3.5	3.6	3.3
Δ-9-*cis*-$C_{18:1}$	21.7	22.7	20.8	22.3	19.4
Δ-11-*cis*-$C_{18:0}$	1.2	2.3	2.1	2.2	2.1
$C_{18:2}$	51.1	51.3	53.0	52.0	53.8
$C_{18:3}$	12.0	8.0	9.4	8.7	10.4
NDF	34.4	33.8	33.3	32.9	32.7
ADF	21.1	19.9	19.7	19.2	19.0
Ash	6.5	7.1	6.9	6.9	6.8
Ca	0.7	0.8	0.8	0.8	0.8
P	0.4	0.4	0.4	0.4	0.4
Mg	0.3	0.2	0.2	0.2	0.2

[1)] RS = Raw soybeans, E120, E130, and E140 = soybeans extruded at 120, 130, and 140℃, respectively.

Milk yield recorded at wk 4 and 8 was lower for cow fed RS(32.8kg/d) than for those fed ES(37.1kg/d). The lower milk yield of cow fed RS could not be attributed to DMI because DMI of RS and ES treatment were not different.

2. Milking Composition

Neither RS or ES, regardless of extrusion temperatures had an effect on the percentage of yield or milk fa. Milk protein percentage was higher for cows fed RS than those fed ES. However, CP yield was not different among treatments. Increased milk yield combined with a decreased milk protein percentage for cows fed ES may explain this effect. However, a decrease in milk protein percentage when cows were fed ES compared with that when cows were fed RS. Finally, that higher milk yield observed for cows fed ES than for cows fed RS might have diluted the protein content of milk, resulting in a lower percentage of protein in milk for cows fed ES than for cows fed RS. Lack of effect on milk protein yield supports this hypothesis. Milk lactose content was not affected by dietary treatment. The osmotic relationship of lactose and milk secretion makes its concentration stable despite differences in diet composition. Differences in the percentage of milk SNF reflected differences in protein content, and changes in TS were the sum of the changes in fat(although not statistical significant) and protein percentages.

3. FA

Compared with RS, the addition of ES to the diets, regardless of extrusion temperature, decreased the proportion of many FA up to a chain length of $C_{16:0}$ in milk fat. This lower proportion of short and medium chain FA indicated a decrease in the *novo* FA synthesis within the mammary gland. Moreover, ES increased the proportion of Δ−11−*trans*−$C_{18:1}$ from 2.72 to 11.41% in milk fat. This relatively high concentration of Δ−11−*trans*−$C_{18:1}$ in milk fat could be responsible for the decrease in the proportion of short and medium chain FA. Furthermore, RS and ES yielded a similar proportion of Δ−9−*cis*−$C_{18:1}$ in milk fat. The proportion of $C_{18:0}$, $C_{18:2}$, and $C_{18:3}$ were higher in the milk fat of cows fed RS than in the milk fat of cows fed ES.

As in milk fat, $C_{18:0}$ and $C_{18:2}$ were lower, and Δ−11−*trans*−$C_{18:1}$ were higher, in serum FA from the jugular vein of cows fed ES than in serum FA of cows fed RS. However, $C_{18:3}$ in the total serum lipid fraction, which was higher in the milk fat of cows fed RS, was not effected by dietary treatments.

CONCLUSION

Under the condition of this experiment, milk yield increased more when ES were incorporated in the diet than when RS were incorporated in the diet. Milk CP percentage was lower for cows fed ES than for cows fed RS, but the proportions of other milk constituents were independent of the extrusion process or extrusion temperatures. The proportion of −11−*trans*−$C_{18:1}$ in milk fat was higher for cows fed ES than for cows fed RS, but the proportions of $C_{18:0}$, and $C_{18:3}$ were lower. Extrusion temperature, within the range of 120 to 140℃, had only minor effects on milk FA profile.

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