Effect of Heating of Soybean Meal on *In Vitro* Digestibility and Feeding Value for Lactating Dairy Cows

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Story in Brief

Soybean meals (SBM) subjected to different amounts of heating in a flash desolventizing system were characterized in terms of protein dispersion index (PDI), total protein, soluble nitrogen and available lysine. With increased PDI values, nitrogen solubility and available lysine were increased. *In vitro* microbial digestibility of dry matter and protein was reduced by additional heating of SBM during processing. Enzymatic digestion was increased so that total disappearance of dry matter and protein was reduced only a small amount.

Twenty-two lactating dairy cows were utilized in a feeding trial to evaluate the effects of heat-treated SBM (PDI-10) versus regular SBM (PDI-40) on animal performance. The two types of SBM were compared at two different levels of protein intake. Parameters measured were feed intake, milk yield and composition, and weight change.

At the higher level of protein, that from SBM was about 59 percent of the total protein intake, and at the lower level it was around 32 percent. Cows at the higher level of protein intake produced more milk than those at the lower level. Milk yield of cows fed heat-treated SBM was higher than that of cows fed regular SBM, particularly in the lower protein group where total protein intake was slightly below requirements. Efficiency of protein utilization by dairy cows appeared to be improved by heating SBM more than is required for production of that commonly available in the feed trade.

Introduction

World demand for protein has increased awareness of the need to increase the efficiency of utilizing feed protein. The protein needs of a high producing dairy cow can become critical; therefore, maximizing quantity and quality of protein reaching the small intestine for absorption is important. Methods for heat treating soybean meal (SBM) that enable a larger fraction of the protein to pass without breakdown through the rumen into the lower digestive tract have been investigated in recent years.

In a Texas feeding study in which rations classified as having proteins of low or high solubility were fed to lactating cows, an 11 lb per day increase in milk yield was observed in favor of the ration with protein of lower solubility. South Dakota workers reported a 15 percent increase in milk yield when heat-treated soybean meal replaced regular SBM in rations for dairy cows during the first 15 weeks of lactation.

Different laboratory methods have been utilized to estimate the solubility of proteins and thereby predict their potential for escaping rumen degradation. One such method (A.O.C.S. Official Method Ba 10-65) expresses solubility of feed proteins in terms of a protein dispersion index (PDI). The PDI value can be defined as the percentage of total protein which is dispersible in water under controlled conditions of extraction. This index has been used as an indicator of the amount of nitrogen that is available for microbial use in the rumen.

The objectives of this study were to evaluate *in vitro* digestibility of soybean meals subjected to different amounts of heating, and to compare the feeding value of regular SBM with meal heated more extensively during processing.

Materials and Methods

In Vitro Digestibility Trial

Soybean meals that had been processed by the flash desolventizing system with exposure to various amounts of heating were characterized by PDI, total protein, soluble nitrogen and available lysine. With this method of processing, a product is obtained over a wide range of PDI values. A lower PDI value indicates a greater degree of heat treatment.

A two-stage *in vitro* digestion procedure was used to measure the disappearance of dry matter and nitrogen of SBM. The first stage consisted of a 12-hr incubation of 500 mg aliquots of the soybean meals in a rumen fluid-buffer solution at 37° C. After incubation, one-half of the samples were dried and one-half (replicates) were subjected to pepsin digestion for an additional 12 hr. The disappearance of dry matter and nitrogen content after each stage of digestion were determined.

Feeding Trial

Soybean meal with a PDI value of 10 and regular SBM (PDI-40) were compared in a feeding trial using lactating dairy cows. Four rations were formulated so that energy content, expressed as the net energy for lactation (NE_l), was kept constant. The two types of SBM were included in rations fed at two protein levels (Table 1). Rations

Table 1. Composition of concentrate mixtures.

Item	Protein level	
	High	Low
	(%, as fed)	
Ingredients		
Corn, ground	63.5	84.5
Soybean meal	34.0	13.0
Dicalcium phosphate	1.5	1.5
Limestone	.5	.5
Salt	.5	.5
Calculated protein content, %	22	14

for the high protein group provided 131 percent of the protein specified by the National Research Council (NRC) feeding standard, with the grain mix containing 22 percent protein. Rations for the low protein group provided 94 percent of the protein indicated by the standard with 14 percent protein in the grain mix. It was intended that the protein levels would be 70 and 100 percent of the NRC standard; however, milk yields of the cows were lower than anticipated, resulting in higher protein intakes as indicated. The only difference within the high and low protein groups was the treatment of SBM, being either HT-SBM (PDI-10) or regular SBM (PDI-40). On a dry matter basis all four rations consisted of 60 percent grain mix, 24 percent sorghum silage and 16 percent sudangrass hay.

Prior to initiating the study, 22 cows (18 Holsteins, four Ayrshires) were adjusted to rations with a 60:40 concentrate to forage ratio. The cows ranged from 6 to 15 weeks postpartum when started on trial. A switchback design with 4-week periods allowed each cow to be fed each type of SBM in a planned sequence. Only the data collected during the last 2 weeks of each period were used in comparing treatments to minimize any carryover effects between periods. Initial feed allowances were based on size of cow, age and estimated production potential; these were reduced by 5 percent at the end of each period. Cows were fed in individual stalls twice daily, and feed weighbacks were recorded daily. Cows were weighed on three consecutive days at the end of the adjustment period and at the end of each experimental period.

Representative samples of all feeds fed were analyzed for dry matter and protein. Individual cow milk yields were recorded twice daily, and samples were collected at four consecutive milkings each week for total solids and milk fat determination. Protein analysis was conducted on milk samples during the fourth week of each period.

Results and Discussion

In characterizing soybean meals (Table 2), a trend was observed with different PDI values. Using regular SBM (PDI-40) as a standard, as PDI values decreased due to a greater amount of heating, nitrogen solubility and available lysine also decreased. Thus, dairy cows having a high dietary protein requirement would theoretically be expected to increase their performance when fed SBM of a lower PDI value.

There was a substantial decrease in microbial *in vitro* dry matter digestibility and disappearance of SBM nitrogen as PDI values of the SBM decreased (Figure 1). It appeared that the SBM protein with a lower PDI value was more protected from microbial breakdown under the conditions of this test. Enzymatic digestion of the SBM

Table 2. Characteristics of soybean meal.

PDI[a]	Total protein[b]	Soluble nitrogen[c]	Available lysine[a,d]
	%	%	%
8.2	54.5	8.6	4.47
18.0	54.9	9.6	4.94
30.2	54.0	17.4	5.67
41.8	53.3	14.4	5.24
51.4	52.2	23.8	5.49

[a]Protein dispersibility index; values supplied by Farmland Industries, Inc.
[b]Dry basis.
[c]% of total nitrogen; solubility in NaCl.
[d]% of total protein; determined by binding with 2,4-dinitrofluorobenzene.

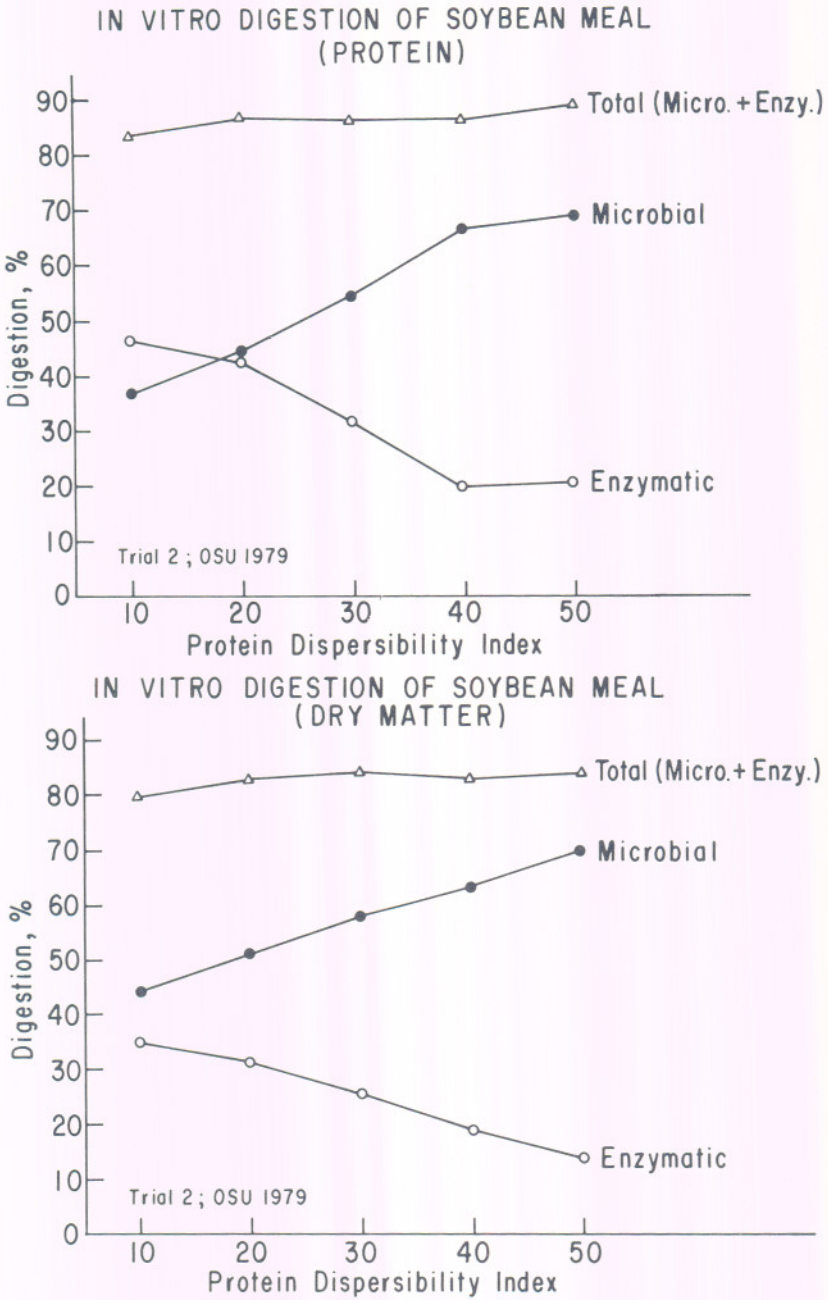

Figure 1. In vitro digestibility of soybean meal in relation to PDI value.

with lower PDI was increased. Thus, the heat treatment of SBM by the flash desolventizing system reduced the degradation of SBM in a rumen fluid environment without drastically reducing total digestion. If one assumes that these results accurately predict what would occur in the digestive tract of a cow, those with a high requirement for protein would be expected to respond favorably to SBM with a lower PDI value.

In the feeding trial, intakes of dry matter by cows were similar in both SBM treatment groups as expected since feed intake was controlled (Table 3). SBM protein represented approximately 59 percent of the total protein intake by the high-protein group and about 32 percent of the total in the lower-protein group. In both groups, SBM protein constituted high enough percentage of the total protein that it was logical for treatment of the SBM to have an influence on production responses. In both protein groups, milk yield was higher for cows fed the PDI-10 SBM than for those fed the regular SBM. The difference between treatment groups was sufficiently large and consistent at the lower protein level to be considered of particular importance. This was a logical outcome since protein intake was estimated to be slightly less than the amount required to meet requirements of the cows for the amount of production obtained. It appeared that the cows benefited from being fed the more extensively treated SBM under conditions where protein was possibly limiting. This is in agreement with results of work at other stations, and indicates potential benefits due to extra heating of SBM that need to be verified in additional trials.

Table 3. Feed intake and milk yield of cows.

Item	SBM treatment	
	PDI-40	PDI-10
High protein group		
Feed intake		
Total DM, lb/day	42.1	41.9
Total protein, lb/day	7.2	7.4
SBM protein, % of total	59.2	59.3
Milk yield		
Milk, lb/day	53.4	54.7
Fat, %	3.91	3.90
Protein, %	3.39	3.37
Milk/feed DM	1.24	1.28
Low protein group		
Feed intake		
Total DM, lb/day	41.1	41.2
Total protein, lb/day	4.9	5.0
SBM protein, % of total	31.8	32.5
Milk yield		
Milk, lb/day	48.1[a]	49.6[b]
Fat, %	3.87	3.85
Protein, %	3.28	3.31
Milk/feed DM	1.16[a]	1.20[b]

[a,b]$P<.05$.

Higher milk yield by cows at the higher protein level and by cows fed PDI-10 SBM within protein levels was reflected in greater gross efficiency of milk production, as expressed in terms of unit weight of milk per unit weight of dry matter intake. Presumably, less degradation of protein in the PDI-10 SBM in the rumen allowed more high quality protein to bypass the rumen and be absorbed from the small intestine. If so, more high quality protein was available for milk production. Although the differences in weight change between SBM treatment groups within protein levels were not of real importance, cows at the higher protein level did gain some weight, whereas those in the lower protein group did not. This was consistent with higher milk production by the higher protein group, which reflected some need for protein beyond that received by the lower protein group.