EFFECT OF PROCESSING OF SOYBEANS ON RELEASE OF FREE FATTY ACIDS AND SUBSEQUENT EFFECTS UPON FIBER DIGESTIBILITIES

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Summary

Two in vitro experiments were conducted to determine the rates of lipolysis and biohydrogenation of fat from raw or processed soybeans and to examine subsequent effects upon fiber digestibilities. In experiment 1, substrates containing soy oil; raw soybeans; extruded soybeans; and soybeans roasted at 270,295, or 325 °F were incubated with ruminal contents for 2, 4, 6, 12, or 24 hr, and release of free fatty acids was measured. The fatty acids released from substrates containing soy oil, extruded soybeans, and raw or roasted soybeans reached maximums at 4, 6, and 12 hr incubations, respectively. Fatty acids in roasted soybeans were subjected to less biohydrogenation than those in raw or extruded soybeans, suggesting that fatty acids of roasted soybeans are protected partially from ruminal bacteria. At all incubation times, the substrates containing soy oil or extruded soybeans had lower and those containing roasted soybeans had higher fiber digestibilities.

(Key Words: Soybeans, Free Fatty Acids, Biohydrogenation, Fiber Digestibilities.)

Introduction

Full fat soybeans contain, on a dry basis, approximately 19% fat and 39% CP. The protein is considered to be of high quality, and the high fat content is attractive because of its ability to increase the energy density of a diet for animals having high energy requirements. The benefits of feeding heat-treated soybeans for dairy cows were attributed to minimizing activity of antinutritional factors and maximizing protein supply at the intestinal level.

Processing methods can influence utilization of soybeans by affecting release of free fatty acids (FFA). For example, the extrusion process ruptures the fat micelles within the soybean, which can allow a more rapid release of oil into the rumen. Roasting of soybeans, followed by steeping at elevated temperatures, can influence fatty acid release by protein and fat interactions. Antibacterial effects of FFA on fiber-digesting bacteria are well documented. The rates of release of fatty acids from whole soybeans and processed soybeans can be different and can affect fiber digestibilities.

The objectives of this experiment were to determine the rates of lipolysis and biohydrogenation of processed soybeans incubated in rumen contents and to examine subsequent effects upon fiber digestion.

Procedures

Experiment 1

Substrates for incubation were soybean meal plus soy oil; raw soybeans; soybeans roasted at 270, 295, or 325°F temperatures; and extruded soybeans; these were designated as control, RB, RSB-270, RSB-295, RSB-325, and ESB, respectively.

Half a gram of substrate was incubated in 40 ml of medium solution and 10 ml of inoculum in a 250-ml Erlenmeyer flask. The inoculum was prepared by collecting whole rumen contents from a rumen-fistulated Holstein steer and straining through two layers of cheesecloth. The incubation was conducted in a shaking water bath for 2,4,6,12, and 24 hr. The FFA released from substrates at different incubation times were extracted and analyzed by using Gas Liquid Chromatography.

Experiment 2

Incubation conditions and substrates for incubation were the same as in Experiment 1 with the following exception: .5 g of ground alfalfa hay was added to each substrate in order to determine the effect of release rate of fatty acids on fiber digestibilities. The fiber determinations used the procedure outlined by Goering and Van Soest.

Results and Discussion

The least square means of FFA released from substrates during different incubation times are presented in Table 1. The FFA releases from control, ESB, and RB or RSB substrates reached their peaks at 4, 6, and 12 hr of incubation, respectively. Fairly rapid release of FFA from extruded soybeans is attributed to the fact that the process ruptured cell membranes and lead to higher availability of oil to external agents. Relatively slow release of FFA from raw or roasted soybeans could be due to intracellular location of oil or chemical changes taking place during the roasting process. As the roasting temperature increased from 270 to 325 °F, the release of FFA decreased at 2, 12, and 24 hr incubations.

Biohydrogenation of unsaturated C18 fatty acids is presented in Table 2. Biohydrogenation of C18:1 was higher for control and RB, medium for ESB, and low for RSB substrates, suggesting that fatty acids of RSB are protected partially from ruminal bacteria. Similar trends of biohydrogenation were observed for C18:2 in all the substrates. Biohydrogenations of all unsaturated C18 in control, RB, ESB, and RSB substrates were 77.8, 77, 67.2, and 55.5%, respectively.

The least square means of NDF and ADF digestibilities of substrates at different incubation times are presented in Table 3. At all incubation times, NDF digestibilities were lower for control and ESB substrates than for RSB substrates. The ADF digestibilities of substrates followed a similar trend.

In conclusion, the release of FFA was faster from substrates containing soy oil or extruded soybeans than from those containing raw or roasted soybeans. Fatty acids in roasted soybeans were less biohydrogenated than those in raw or extruded soybeans. High rates of lipolysis and FFA concentrations were linked to depression in fiber digestibilities for control and ESB substrates.

Table 1. Averages of Free Fatty Acids Released from Substrates during Incubation (n=5)

Incubation time, hr	Substrates[1]						Probabilities for contrast					
	Control	RB	ESB	RSB-270	RSB-295	RSB-325	Control vs Rest	RB vs ESB	RB vs RSB	ESB vs RSB	Roasting temperature	
											Linear	Quadratic
	----------mg/g substrate----------											
2	85.6	66.4	70.2	51.0	46.2	41.4	.01	.13	.01	.01	.01	.84
4	109.6	74.8	88.2	61.8	59.8	54.0	.01	.01	.01	.01	.16	.56
6	92.8	93.6	112.4	73.6	70.0	70.0	.01	.01	.01	.01	.13	.32
12	70.8	100.7	72.2	86.0	83.8	78.2	.01	.01	.01	.01	.01	.12
24	52.2	85.8	61.0	51.0	48.0	43.0	.01	.01	.01	.01	.01	.16

[1]Control = soybean meal plus soy oil; RB = raw soybeans; ESB = extruded soybeans; RSB-270, RSB-295, RSB-325 = soybeans roasted at 270, 295, and 325°F, respectively.

Table 2. Biohydrogenation of Unsaturated C 18 Fatty Acids during Incubation (n=5)

Fatty acid[2]	Substrates[1]						SEM
	Control	RB	ESB	RSB-270	RSB-295	RSB-325	
	%						
18:1[3]	75.5[a]	74.2[a]	64.9[b]	55.3[c]	52.6[c]	50.2[c]	1.8
18:2	80.8[a]	79.8[a]	66.4[b]	58.3[c]	56.6[c]	53.8[c]	1.1
Total C18[4]	77.8[a]	77.0[a]	67.2[b]	58.7[c]	55.4[c]	52.3[c]	1.7

[abc]Means with different superscripts in the same row differ ($P < .05$).

[1]Control = soybean meal plus soybean oil; RB = raw soybeans; ESB = extruded soybeans; RSB-270, RSB-295, RSB-325 = soybeans roasted at 270, 295, and 325°F, respectively.

[2]C18:3 not listed because of its low content in substrates.

[3]Number of carbons:number of double bonds.

[4]C18:1 + C18:2 + C18:3.

Table 3. Averages of NDF and ADF Digestibilities of Substrates Used in Experiment 2 (n=4)

Incubation time, hr	Substrates[1]						Probabilities for contrast					
	Control	RB	ESB	RSB-270	RSB-295	RSB325	Control vs Rest	RB vs ESB	RB vs RSB	ESB vs RSB	Roasting temperature	
											Linear	Quadratic
	%											
NDF digestion												
2	8.2	11.4	7.9	11.6	13.9	12.7	.01	.01	.04	.01	.16	.01
4	10.2	18.5	13.2	17.5	19.9	19.2	.01	.01	.39	.01	.01	.01
6	12.1	20.1	16.0	21.0	22.7	21.1	.01	.01	.10	.01	.99	.04
12	18.7	24.4	20.1	26.6	30.2	24.9	.01	.01	.11	.01	.02	.01
24	41.1	56.4	52.4	55.9	56.8	55.7	.01	.02	.68	.01	.94	.92
ADF digestion												
2	5.1	9.2	7.1	9.4	9.7	9.6	.01	.01	.13	.01	.43	.48
4	8.6	15.1	10.5	14.8	15.6	16.1	.01	.01	.27	.01	.01	.62
6	11.1	17.2	12.0	18.1	18.0	18.1	.01	.01	.10	.01	.98	.78
12	15.5	20.4	19.1	21.1	21.9	21.0	.01	.01	.13	.01	.58	.09
24	36.4	51.2	48.2	52.1	53.2	54.1	.01	.01	.14	.01	.01	.01

[1]Control = soybean meal plus soy oil; RB = raw soybeans; ESB = extruded soybeans; RSB-270, RSB-295, RSB-325 = soybeans roasted at 270, 295, and 325°F, respectively.