



IFAS EXTENSION

Feeding Raw or Heat-treated Whole Soybeans to Dairy Cattle ¹

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Whole ground or rolled soybean seed (raw soybeans) is a very good protein supplement for dairy cows. Feeding trials and farm experiences with feeding raw soybeans are numerous. Morrison stated in the 1959 edition of *Feeds and Feeding* that ground or cracked soybeans are well liked by dairy cattle when fed in such amounts as are needed to balance the ration.

Soybeans are not recommended for all classes of animals. Raw soybeans are not well utilized by single stomached animals such as swine and poultry. Heat treatment is recommended when used for such animals in order to inactivate enzymes and enzyme inhibitors.

Dry whole soybeans (90% DM) contain about 38% protein, 82% TDN, 17% fat and 8.9% acid detergent fiber (ADF). In comparison, soybean meal is marketed to contain 44% and 48% protein, 75-77% TDN and 1-2% fat (solvent-extracted).

A comparison of the composition values for soybeans and soybean byproducts is shown in Table 1

Ruminant animals such as cattle, sheep and goats can utilize soybeans without being processed. Even so, warnings frequently occur on feed tags, even for dairy animals. The reason for this warning usually involves the use of urea or similar compounds. Raw soybeans contain an enzyme called urease, and when in contact with urea, destroys the efficient use of urea. Mixed feeds containing both urea and ground raw soybeans will gradually gain an ammonia smell upon storage. Because of the breakdown of urea and the releasing of ammonia, urea should not be added to rations containing ground raw soybean. Heat-treating the raw soybeans inactivates the urease enzyme, increases the storage life of the beans by destroying the lipase enzyme, and increases the bypass protein content of the soybeans.

In recent years, research has demonstrated the importance of bypass (undegradable) intake protein for high-producing cows. Bypass protein is that protein that escapes rumen fermentation and is available for absorption in the small intestine. As milk production increases, a substantial amount of dietary protein must escape rumen fermentation to meet the animal's requirement for protein. In general, it has been calculated that about 35%-40% of the

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total protein should be bypass protein. In Arizona studies where cows responded to bypass protein, milk yield generally exceeded 65 lb/day (3,4).

The question that frequently arises is where do we get bypass protein? The major sources used by dairymen are distillers dried grains, brewers grains, corn gluten meal, fish meal and feather meal. Also, heat-treating feedstuffs such as soybeans and soybean meal increases the bypass content of the supplement. As an example, when soy protein is heated at 230°F, it remains quite soluble in the rumen. However, if that same soybean meal is heated to approximately 280°F (138°C), then it becomes high bypass protein.

A number of studies have been conducted over a period of several years comparing the feeding value of whole raw soybeans to soybean meal and whole soybeans to roasted soybeans. A few of those studies will be reviewed and discussed.

Research Studies

A recent study by Canadian researchers (5) compared two levels of protein and raw versus heat-treated soybeans for first-lactation Holstein cows. All soybeans were ground prior to feeding. The 28 cows were fed one of four rations that provided either 7.4 lbs (raw or heat-treated) per day or 12.8 lbs (raw or heat-treated). Corn silage was the only forage and accounted for 64.5% of the ration dry matter. Rations were formulated to contain similar amounts of energy and two levels of protein (15.4% and 20.7%). Only first-calf heifers were used in the experiment and were started at approximately nine days after calving. The results are given in Table 2 .

In the Canadian study, neither dry matter intake nor fat-corrected milk (FCM) was affected by the heat-treatment of soybeans. The higher level of protein (20.7%) in early lactation tended to improve actual milk production but not significantly ($p > .05$). Production of FCM was significantly ($p < .05$) higher for the high protein and high soybean rations. Fat percent was improved by feeding the higher levels of soybeans. The study suggests that fairly high levels of soybean (12.8 lbs) may be fed in rations containing high levels of corn silage. This study did not show

any economic advantage in using heat-treated soybeans over raw soybeans.

In a Pennsylvania study (1), 28 Holstein cows were used to compare the feeding value of heated or unheated soybeans in complete rations. Each ration contained 65% silage, 31% soybeans and 4% vitamin-mineral supplement (dry basis). Results are shown in Table 3 .

Actual milk production and dry matter intake was not different between soybean types (Table 3). The fat percent ($P < .01$) by cows fed the heat-treated soybean ration was severely depressed (2.46 vs. 3.84). Because of the depressed fat test, FCM production was lower ($p < .01$) by cows fed heated (H) soybeans.

Under these study conditions, feeding high quantities (about 13.2 lb/d) of H soybeans was detrimental to animal performance by severely reducing the milk fat test, altering rumen fermentation, and increasing the incidence of ketosis.

Kansas workers (9) evaluated and compared the feed of raw and heat-treated soybeans against a control ration with soybean meal. The raw and heated soybeans were rolled before being mixed into the concentrate mixture. Alfalfa hay and concentrate were consumed *ad libitum* in a ration of 35% hay and 65% concentrate. The processed soybeans were heated in a California Pellet Mill Jet-Sploder. The results are given in Table 4 .

Milk production and percent protein values in Table 4 were significantly greater when cows were fed soybean meal or Jet-ploded full-fat soybeans than when fed raw soybeans. Percent milk fat and total milk solids were not affected by treatment. Lower consumption of the raw soybean ration (5 lb/day of raw soybeans) compared to either of the other rations appears to be the only reason for the response difference.

In a South Carolina trial (2), O'Dell compared the feeding of raw and heat-treated soybeans in both first lactation and older cows. The two groups were fed an identical corn silage and concentrate ration in addition to the five pounds of soybeans given daily per cow. The results are in Table 5 .

Older cows fed extruded soybeans produced more milk than those fed raw soybeans, but the milk fat test was significantly lower resulting in no difference in 4% FCM. Percent fat was significantly less for the cows receiving extruded beans.

In a California study (8), extruded soybeans were compared to the feeding of ground raw soybeans in rations containing 7% soybeans, amounting to 3-4 lbs daily per cow. Alfalfa hay was fed as the source of forage. The results are in Table 6 .

The California study showed a significant increase in milk production when using extruded soybeans with little to no change in fat percent. A fairly low level of soybeans was fed during early lactation. The author suggested that the beneficial effect on milk production may have been due to the source of roughage in combination with the added bypass protein in early lactation.

In a South Dakota study (6) raw and heat-treated soybeans (HTS) were compared to a control ration containing soybean meal. Concentrate rations were fed at 1 lb/3 lbs of milk produced. Forages consisted of 5 lbs of alfalfa hay and corn silage *ad libitum* . Cows consumed an average of 35 lbs of silage and 5 lbs of soybeans daily. The results are given in Table 7 .

Milk production was similar for all treatments (Table 7), although yields of both milk and 4% FCM were largest when heat-treated soybeans (HTS) were fed. Milk production was not affected by protein solubility or fat content of the diets.

Whole Soybean Ration Formulations

A number of farmers grow soybeans in Florida. In some cases, it may be more cost effective to feed the whole soybeans rather than market them and purchase soybean or peanut meal. The following two rations for 90 lbs and 65 lbs of 4% milk have been formulated to contain whole soybeans. Alfalfa hay was used for the high herd (90# milk) (Table 9) and bermuda hay for the medium high herd (65# milk) (Table 8).

A number of studies have been conducted comparing the use of roasted or heat-treated whole soybeans with raw soybean. The results obtained are not consistent and seem to vary with source of roughage, stage of lactation and age of cow. Although we do not know all the reasons for the varying results from feeding heat treated soybeans, there are some guidelines that can be drawn from existing studies:

1. Extruded or heat-treated soybeans have more bypass protein than raw soybeans and are more likely to have a beneficial effect on milk production when fed to high-producing cows in early lactation.
2. Extruded whole soybeans fed at the rate of 12-15 pounds per cow daily can result in severe milk fat depression. Lower levels (4-5 lbs) should be fed under some feeding situations. Higher levels have been used with success in high-corn silage rations and first-lactation cows.
3. Alfalfa hay rations appear to give better results and a more consistent fat percent than corn silage rations with the use of heat-treated soybeans.
4. Most studies have not demonstrated any real advantage in using heat-treated soybeans over raw crushed soybeans. Soybean meal rations have usually given results equal to either heat-treated or raw crushed soybean-type rations.
5. Course grinding, rolling, or crimping to improve digestibility of whole soybeans is recommended. Proper storage and frequent grinding of the raw whole soybeans prevent fat from becoming rancid. Mixing soybeans with some corn or other feedstuffs prior to grinding helps prevent "gumming."
6. Do not feed ground raw soybeans with feeds containing urea since the enzyme urease is present in the soybeans. When using soybeans, increase the level in the ration gradually in order to avoid possible "off feed" problems.
7. The value of the soybeans in the ration will vary some with quality of the bean. Whole soybeans are worth about 92% the value of 44% soybean meal.

In conclusion, both raw soybeans and heat-treated soybeans can be used in rations for lactating dairy cows. Heat-treated soybeans provide more bypass protein and may have an advantage in very early lactation. Since soybeans are high in fat, a depression in fat percent may occur in some situations, especially when using roasted or heat-treated soybeans. Most studies show more positive results when the whole soybeans are used in conjunction with adequate amounts of roughage and preferably with some alfalfa hay. Alfalfa hay appears to have a positive effect on milk fat percent by perhaps increasing the buffering capacity of the ration.

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Table 1.

Table 1. Composition values of soybeans and byproducts (as fed).						
	CP	PB	TDN	NEL	ADF	RV
	(%)	(%)	(%)	Mcal	(%)	(\$)/ton
Soybeans, whole	38	26	82	86	8.9	235
Soybean meal (44)	44	35	75	79	8.9	260
Soybean meal (48)	48	35	77	79	5.3	280
Soybean hulls	11	10	69	70	44.5	109
Soybeans, roasted	38	65	84	89	8.0	237

CP=Crude protein; PB=Protein Bypass; TDN=total digestible nutrients; ADF=acid detergent fiber; RV=relative value (will vary since prices are based on current cost of soybean meal); NEL=net energy for lactation.

Table 2.

Table 2. Least square means of average milk, 4% FCM, and milk composition from cows receiving different forms of soybeans.						
	% Sol.	% Soybeans	DMI (lb)	Milk (lb)	% Fat	FCM (lb)
Low CP (15.9%)	LS (24.9)	19*	37.6	58.6	3.55	53.9
Low CP (14.8%)	HS(48.2)	19	40.5	61.6	3.60	57.8
High CP (21.3%)	LS(20.6)	33*	40.7	64.8	3.88	63.5
High CP (20.2%)	HS(57.8)	33	36.7	61.8	4.05	62.3

*Rations 1 and 3 were heat-treated soybeans. CP=crude protein; DMI=dry matter intake; FCM=fat-corrected milk. LS=low solubility. Percent soybeans were on a dry matter ration basis.

Table 3.

Measurement	Soybean Type	
	H	U
DMI (lb/d)	42.70	43.80
Milk Yield (lb/d)	73.70	72.10
Fat (%)	02.46	03.84
FCM (4%)	56.80	70.10
Protein (%)	02.96	02.81

Table 4.

Table 4. Daily dry matter intake, milk yield and milk composition				
Treatment	DMI (lb)	Milk (lb)	Fat %	Protein %
Control	58.0	73.9 ^a	3.51	3.18 ^a
(Soybean Meal)				
Cracked Soybeans ¹	54.4	69.7 ^b	3.57	3.08 ^b
Heated Soybeans ¹	58.4	73.3 ^a	3.57	3.15 ^a
a,bTreatment effect (P< .05). Concentrate contained 82-85% corn and mineral and vitamins plus soybean treatments.				
1Soybeans were fed at the rate of 5-6 lbs/day.				

Table 5.

Table 5. Milk production and composition of milk by cows fed extruded or raw ground soybeans.				
	First calf		Older calf	
Measurement	H	U	H	U
Milk (lb/d)	51.00	51.90	63.60	59.80
Milk fat (%)	02.67	03.07	02.68	03.00
4% FCM (lb/d)	40.80	44.70	51.00	50.80
H=heat treated; U= raw ground soybeans (unheated)				

Table 6.

Table 6. Milk production and fat percent response from feeding heat-treated whole soybeans.		
	Control	Heat-treated
Milk yield (lb/d)	70.80	77.20
Milk fat (%)	03.70	03.74
4% FCM (lb/d)	67.60	74.20

Table 7.

Table 7. Dry matter intake, milk yield and composition from cows fed rations containing soybean meal (SBM), heat-treated soybeans (HTS) and unheated soybeans (UHS).			
	Rations		
	SBM	HTS	UHS
Dry matter intake (lb/d)	46.60	47.30	47.30
Milk (lb/d)	62.90	64.00	62.30
Fat (%)	03.57	03.61	03.53
Protein	03.00	02.92	02.93
FCM (lb/d)	58.30	59.80	57.60

Table 8.

Table 8. Medium-High Herd												
	lbs	DM	CP	PB	TDN	CA	PHOS	K	Mg	Sodium	ADF	NDF
Corn Silage	40.00	12.00	1.00	0.20	8.00	0.04	0.02	0.12	0.03	0.00	3.60	6.60
Bermuda hay	5.00	4.45	0.40	0.10	2.00	0.02	0.01	0.07	0.01	0.01	1.60	3.25
Corn meal	10.00	9.00	0.86	0.45	8.00	.00	0.03	0.03	0.01	.00	0.30	0.50
Whole Soybean	7.00	6.30	2.66	0.69	5.67	0.01	0.04	0.11	0.02	0.02	0.63	1.40
Soybean Hulls	6.00	5.34	0.72	0.29	3.90	0.02	0.01	0.04	0.01	.00	2.70	2.70
Distillers Grains	4.00	3.60	1.08	0.54	3.20	.00	0.01	0.01	0.00	.00	0.64	1.56
Soybean Meal (48%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mineral	1.20	1.13	0.00	0.00	0.00	0.19	0.07	0.06	0.04	0.16	0.00	0.00
	73.20	41.82	6.72	2.27	30.77	0.29	0.19	0.44	0.12	0.19	9.47	16.01
Requirements(65 # Milk)			6.51		30.00	0.21	0.16					
Dry Matter Percent			16.07	33.73	73.58	0.69	0.46	1.06	0.29	0.45	22.65	38.28
DM= dry matter; CP= crude protein; PB=protein bypass; Ca=Calcium; K=potassium; Mg=magnesium; ADF= Acid detergent fiber and NDF=neutral detergent fiber.												

Table 9.

Table 9. High Herd												
	lbs	DM	CP	PB	TDN	CA	PHOS	K	Mg	Sodium	ADF	NDF
Corn Silage	40.00	12.00	1.00	0.20	8.00	0.04	0.02	0.12	0.03	0.00	3.60	6.60
Alfalfa hay	8.00	7.12	1.44	0.36	4.16	0.06	0.02	0.14	0.02	0.01	2.56	3.84
Corn meal	15.00	13.50	1.29	0.67	12.00	.00	0.05	0.04	0.01	.00	0.45	0.75
Whole Soybean	6.00	5.40	2.28	0.59	4.86	0.01	0.03	0.10	0.02	0.02	0.54	1.20
Soybean Hulls	6.00	5.34	0.72	0.29	3.90	0.02	0.01	0.04	0.01	.00	2.70	2.70
Distillers Grains	4.00	3.60	1.08	0.54	3.20	.00	0.01	0.01	.00	.00	0.64	1.56
Soybean Meal (48%)	2.00	1.80	0.96	0.48	1.56	.00	0.01	0.04	0.01	.00	0.18	0.30
Mineral	1.40	1.32	0.00	0.00	0.00	0.21	0.08	0.07	0.05	0.18	0.00	0.00
	82.40	50.08	8.77	3.13	37.68	0.36	0.24	0.55	0.15	0.22	10.67	16.95
Requirements(90 # Milk)			8.50		37.20	0.33	0.21					
Dry Matter Percent			17.51	35.71	75.25	0.71	0.47	1.11	0.29	0.44	21.31	33.85

DM= dry matter; CP= crude protein; PB=protein bypass; Ca=Calcium; K=potassium; Mg=magnesium; ADF= Acid detergent fiber and NDF=neutral detergent fiber.