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UTILIZATION OF SOYBEAN HULLS IN SUPPLEMENTATION PROGRAMS FOR BEEF CATTLE

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Forage Quality And The Need For Supplementation

Forage forms the basis for cattle nutrition in Florida. Due to minimal pasture growth during the late fall and winter and generally low quality of hay fed, winter nutrition programs for heifers after weaning and lactating cows are typically inadequate. Crude protein and total digestible nutrient (TDN) requirements for gestating and lactating cows and developing heifers are shown in Table 1. These requirements can be related to quality of the forage fed, and used to determine type and quantity of supplement needed.

Table 1. Crude protein and total digestible nutrient (TDN) requirements of breeding and growing beef cattle.

	Crude protein		TDN	
	%	lbs	%	lbs
1000 lb cow, last third of pregnancy	8.0	1.6	55	10.5
1000 lb cow, nursing a calf	10.0	2.0	60	12.0
850 lb first calf heifer, last third of pregnancy	9.0	1.6	60	11.0
850 lb first calf heifer, nursing a calf	10.5	2.0	65	12.0
500 lb growing heifer	11.5	1.4	65	9.0

(Source: NRC, Nutrient Requirements of Beef Cattle, 6th Ed. 1984).

A significant amount of research has been conducted concerning changes in quality of Florida forages as they mature. Moore and Ruelke (1978) studied the influence of advancing maturity upon the quality of bermudagrass and digitgrass (Table 2). Crude protein and TDN content declined rapidly as forage harvest was delayed, with values below animal requirements by 6 to 8 weeks of regrowth. Feed intake values also declined as the hays became more mature. Therefore, advancing maturity has a double-negative effect upon hay feeding value; less of a lower digestible material is consumed.

Table 2. Maturity effects on the feeding value of tropical grass hay.

	Weeks of regrowth					
	2	4	6	8	10	12
Bermudagrass						
Crude protein	20.0	14.0	9.0	8.0	7.0	6.0
TDN	63.0	58.0	55.0	48.0	46.0	45.0
Intake	2.7	2.7	2.5	2.0	2.0	1.9
Digitgrass						
Crude protein	18.0	12.0	10.0	10.0	8.0	7.0
TDN	65.0	62.0	62.0	59.0	52.0	53.0
Intake	2.6	2.5	2.2	1.6	1.5	1.6

(Source: Moore and Ruelke, 1978).
Crude protein, %; TDN - total digestible nutrients, %; Intake, % of body weight.

Table 3 shows the crude protein and TDN concentrations of hay samples submitted by Florida livestock producers to the Extension Forage Testing Program. The average protein value of all samples submitted was 7.4%, and only 21% of the samples were greater than 10% protein. The average TDN value of all samples was 49.4%, with a minimum value of 40.0% and a maximum value of 60.0%. Only 4% of all samples were above 55% TDN and only 43% were above 50% TDN. These data show that most hay produced in Florida will have to be supplemented with energy and protein to meet animal requirements.

Table 3. Crude protein and total digestible nutrient (TDN) concentration of hay samples submitted to the Florida Extension Forage Testing Program.

Crude protein		Total digestible nutrients	
Mean	7.4	Mean	49.4
Minimum	1.9	Minimum	40.9
Maximum	15.9	Maximum	60.8
Crude protein distribution		TDN distribution	
< 4.0	8	40.0 - 44.9	12
4.0 - 5.9	27	45.0 - 49.9	45
6.0 - 7.9	26	50.0 - 54.9	39
8.0 - 9.9	18	55.0 - 59.9	4
10.0 - 11.9	13		
12.0 - 13.9	5		
> 14.0	3		

Soybean Hull Production

Soybean hulls are a product of the soybean processing industry. The soybean hull is the seedcoat of the soybean seed and not the pod. The pod is left in the field during soybean harvest, while the soybean hull is removed from the bean during processing.

During processing, soybeans are rolled to remove the hull from the seed. The hull is light in weight and once the seed and hull are separated, the hull is removed by air. The soybean hull is then toasted and ground. Hulls are blended with the meal to produce 44% crude protein (CP) soybean meal, but when high-protein soybean meal (49% CP) is produced, hulls are available on the market. Poultry nutritionists and most swine nutritionists in the United States prefer high-protein soybean meal, so soybean hulls are usually available on a year-round basis. Also, in recent years most soybean meal exported from the US is high-protein, contributing to the constant supply of soybean hulls for ruminant feeding. Future projections suggest a constant year-round supply of soybean hulls. Current price of soybean hulls is $95 to 100 per ton delivered in 20 ton bulk loads to south-central Florida.

Soybean Hulls: Rumen Filler Or Energy Source

Many seed hulls are low in nutritive value, and are often thought of as 'rumen fillers'. Because of this, many people think of soybean hulls as a low quality feed. Soybean hulls are high in fiber, but the fiber is rapidly and extensively digested.

Cleaned soybean hulls average 8 to 9% crude protein (CP; Table 4). Commercially available soybean hulls often average 12 to 14% CP, because small amounts of soybean meal and bits of whole soybean are not completely removed during processing. Soybean hulls are high in neutral detergent fiber (NDF) concentration. But they are low in lignin content, and the cellulose and hemicellulose components of the cell wall are very digestible. In vitro organic matter digestion (IVOMD) is high and averages 78 to 80%. The cell wall of the soybean hull is digested rapidly (approximately 7.0%/hr; the value for a typical Florida-grown hay would be 3.0 to 4.0%/hr). The cell wall of the soybean hull is also digested to a large extent (approximately 95%; the value for a typical Florida-grown hay would be 40 to 50%).

By way of comparison, chemical composition and in vitro digestion of other grain and oil-meal seed hulls are presented in Table 4. All of these feeds are high in fiber. Like soybean hulls, corn fiber is low in lignin concentration and high in IVOMD. Corn fiber differs from soybean hulls in that the major component of the cell wall is hemicellulose with smaller quantities of cellulose, while the cell wall of soybean hulls is composed primarily of cellulose with smaller quantities of hemicellulose. Corn fiber is the seed coat of the corn grain, just as soybean hulls are the seed coat of the soybean seed. Cottonseed hulls and oat hulls are also high in fiber, but lignin makes up a greater proportion of the cell wall structure. This contributes to the lower digestibility and feeding value of these two by-product feeds. The rapid and complete digestion of feeds such as soybean hulls and corn fiber classifies them as energy supplements and not rumen fillers.

Table 4. Chemical composition and in vitro digestion of various grain and oil-meal seed hulls.

Item[a]	Soybean hulls[b]	Cottonseed hulls[c]	Corn fiber[c]	Oat hulls[c]
Crude protein, %	9.4	12.4	11.3	6.9
NDF, %	74.0	73.5	65.1	69.4
Cellulose, %	47.0	41.5	14.4	31.1
Hemicellulose, %	23.0	12.6	48.7	32.0
Lignin, %	4.0	19.4	2.0	6.3
IVOMD, %	78.0	47.4	87.6	65.8
Rate of NDF digestion, %/hr	7.0			
Extent of NDF digestion, %	95.0			

[a] NDF = neutral detergent fiber, IVOMD = in vitro organic matter digestion.
[b] Anderson et al., 1988.
[c] Hsu et al., 1987.

Starch - Sugar - Fiber: Associative Effects

Because tropical grass pasture during the winter and most hays produced in Florida are high in fiber and low in energy, cattle with high nutrient requirements such as lactating cows and developing heifers can not consume enough to meet their nutrient requirements. In these cases, energy/protein supplements are needed. In theory, the amount of supplemental energy required for an animal on a particular forage is the difference between the animal's energy requirement and the intake of energy from the forage. In practice, however, it is generally not possible to meet an animals energy requirement by offering an amount of supplemental energy equal to the difference between the energy requirement and the energy intake from the forage. This is because when a supplement is offered, forage intake may be decreased. This is termed a 'substitution effect'. Also, digestion of the supplement may influence digestion of the forage. This is termed an 'associative effect'.

Associative effects can be both positive and negative. With low-quality forage, small amounts (approximately 1 to 2 lbs.) of an energy/protein supplement may increase forage intake and digestion. This boost in nutrient availability may be adequate to meet nutrient requirements of some cattle depending upon their physiological state. However, lactating cows and developing heifers require greater amounts of supplement to meet their nutrient requirements. As level of supplement feeding increases, negative associative effects on forage digestion may occur.

A common method of increasing energy intake in ruminants fed low-quality forage is to feed a concentrated energy source such as corn or molasses. Grain is high in starch and molasses is high in sugar. While these feeds have increased dietary energy concentration and improved animal performance, moderate to high levels of corn or molasses supplementation have resulted in reduced digestion of the forage component of the diet. Soybean hulls are high in digestible fiber and contain little or no starch or sugar, and have not caused the same level of negative associative effects on forage digestion that have been observed with corn or molasses.

Klopfenstein and Owen (1988) studied the influence of corn or soybean hull supplementation on rumen parameters, diet digestibility and growth by yearling cattle fed a forage-based diet. In their experiments, corn or soybean hulls replaced corn stalklage at dietary levels of 0.0, 12.5, 25.0 or 50.0%. The pH of ruminal contents was measured at various times for up to 24 hours after feeding. Starch in corn is fermented by rumen bacteria at a more rapid rate than the fiber in soybean hulls. This fermentation results in the production of volatile fatty acids which reduces ruminal pH. Bacteria which digest forage are sensitive to ruminal pH. When the pH drops below approximately 6.2, fiber digesting bacteria can be inhibited, and forage digestion can be reduced.

Supplementation with corn or soybean hulls at 25% of the diet (Figure 1) reduced ruminal pH compared to the control. Ruminal pH did not drop below 6.2 for soybean hulls supplemented at 25% of the diet, but did drop below 6.2 for a short time after feeding in steers supplemented with corn at 25% of the diet. When corn or soybean hulls were fed at 50% of the diet, ruminal pH was reduced to a greater extent than that observed when the energy supplements were fed at 25% of the diet (Figure 2). Ruminal pH was reduced below 6.2 in steers fed corn or soybean hulls, with the pH in steers supplemented with corn dropping to approximately 5.7. The reduction in ruminal pH resulting in an inhibition of fiber utilizing bacteria is the main mode of action controlling the negative associative effects of grain supplementation on fiber digestion.

Supplementation effects on ruminal pH were also reflected in dietary dry matter (DM) and fiber digestibilities (Table 5). Total DM intake increased as level of corn or soybean hulls increased in the diet, with no differences between the supplements at each dietary level. For both supplements, dietary DM digestibility increased in a linear manner as supplement level in the diet increased. At a given level of supplement, differences in dietary DM digestibility between corn and soybean hulls were small.

Fig. 1. Changes in rumen pH for control, 25% corn, and 25% soybean hull diets.

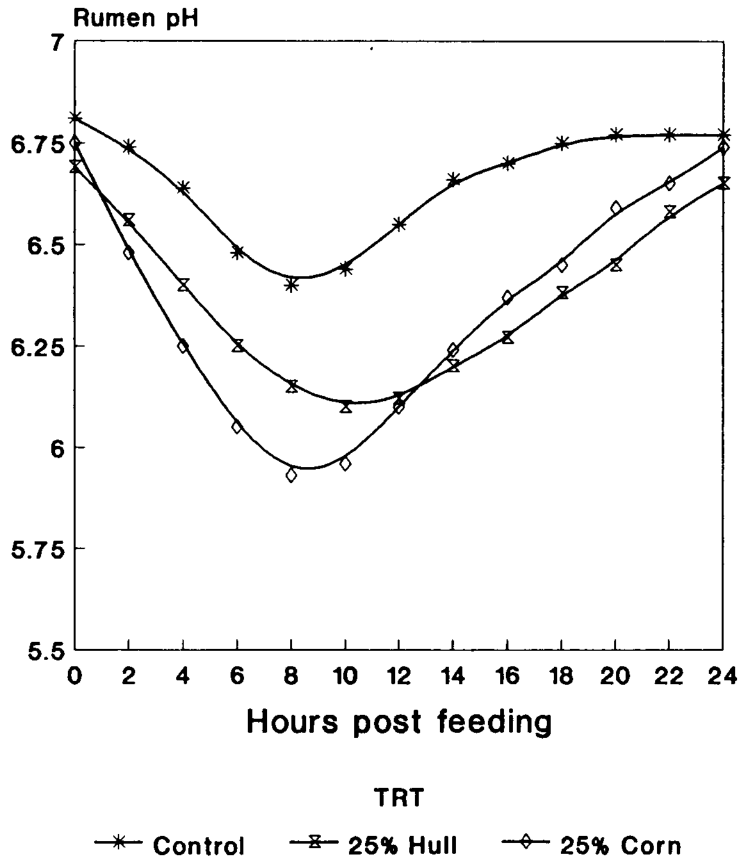

Fig. 2. Changes in rumen pH for control, 50% corn, and 50% soybean hull diets.

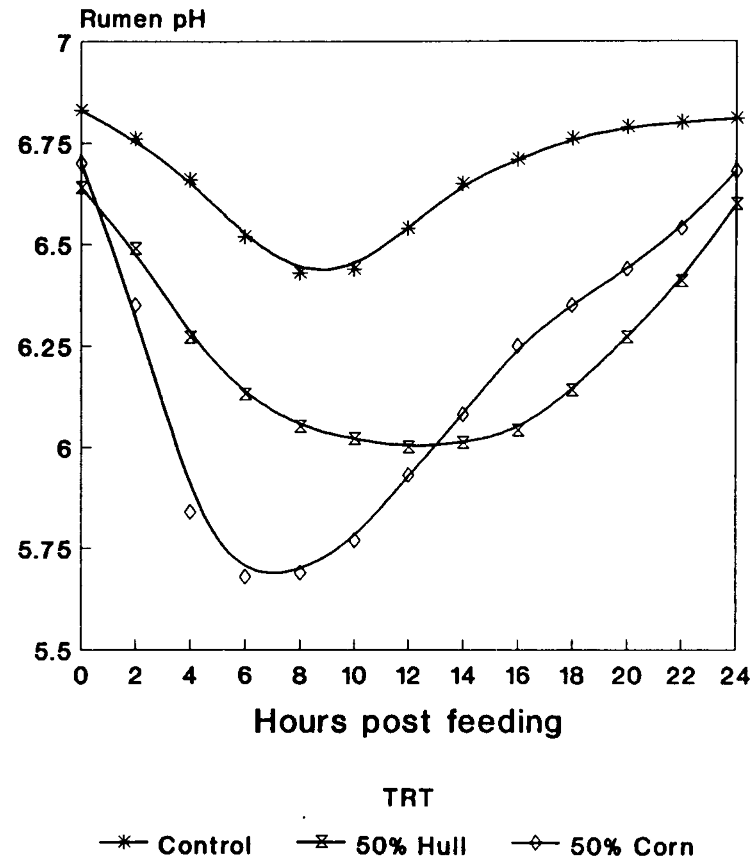

Table 5. Digestibility and growth performance by steers fed a forage based diet supplemented with increasing levels of corn or soybean hulls.

		Soybean hulls			Corn grain		
	Control	12.5%	25.0%	50.0%	12.5%	25.0%	50.0%
Digestion trial							
Daily intake, lbs DM	11.4	12.3	13.4	15.4	12.5	13.0	14.7
DM digestibility, %	53.7	56.4	59.3	63.6	57.3	61.1	65.9
Fiber digestibility, %	49.7	52.5	56.1	61.7	47.1	47.0	39.5
Growth trial							
Daily intake, lbs DM	13.8	15.0	15.4	16.5	13.3	15.0	16.5
Daily gain, lbs	1.1	1.5	1.7	2.0	1.5	1.7	2.1
Feed:gain	13.4	10.0	9.0	8.3	9.2	8.7	7.6

(Source: Klopfenstein and Owen, 1988).
DM = dry matter

Dietary fiber digestibility responded in a different manner (Table 5). As level of soybean hulls increased in the diet, dietary fiber digestibility increased in a linear manner. However, as level of corn supplementation increased, dietary fiber digestibility decreased. This demonstrates the confounding nature of feeding forage and concentrate together. The concentrate is helpful because it provides energy and improves overall dietary DM digestibility, but the concentrate is detrimental because it causes a reduction in forage digestibility and utilization.

In the growth trial, daily gain increased as level of corn or soybean hulls increased in the diet (Table 5). At each level of supplementation, there was no difference in daily gain or feed efficiency between calves supplemented with corn or soybean hulls.

Over the past two years at the Agricultural Research and Education Center - Ona, we have evaluated the relative supplemental energy value of molasses, corn and soybean hulls for yearling cattle grazing bahiagrass pasture during the winter. In each year after weaning in October, calves (530 lbs) were placed on bahiagrass pasture and fed ammoniated stargrass hay. All cattle were also fed 1.0 lb cottonseed meal per head per day. The following supplementation treatments were evaluated (rates are per head per day):

1. control - no additional feed
2. 3.0 lbs DM standard molasses
3. 6.0 lbs DM standard molasses
4. 3.0 lbs DM cracked corn
5. 6.0 lbs DM cracked corn
6. 3.0 lbs DM soybean hulls
7. 6.0 lbs DM soybean hulls

Energy supplements and cottonseed meal were fed three times per week on Monday, Wednesday and Friday.

At the lower level of supplementation, hay intake was not reduced for cattle fed corn or soybean hulls compared to the control (Table 6). At this level, supplementation with corn or soybean hulls was additive to hay intake because hay intake was similar but total intake was greater for these treatments compared to the control. Steers supplemented with molasses at the lower level had reduced hay intake compared to the control. At this level for molasses, the supplementation effect was substitutive because total intake was similar between this treatment and the control.

At the higher level, supplementation with all three energy sources resulted in reduced hay intake compared to the control (Table 6). This supplementation response was both substitutive and additive because although hay intake was lower, total intake for the supplemented cattle was greater than that for the control.

Table 6. Growth performance by steers fed ammoniated stargrass hay supplemented with increasing levels of molasses, corn or soybean hulls.

		Molasses		Corn		Soybean hulls	
	Control	3.0 lbs	6.0 lbs	3.0 lbs	6.0 lbs	3.0 lbs	6.0 lbs
<u>Year 1</u>							
Daily Intake, lbs DM							
Hay	15.2	13.0	13.6	15.0	12.1	15.8	13.2
CSM	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Molasses		3.0	6.0				
Corn				3.0	6.0		
Soyhulls						3.0	6.0
Total	16.2	17.0	20.6	19.0	19.1	19.8	20.2
Daily gain, lbs	1.2	1.7	1.9	2.0	2.3	2.0	2.4
Feed/gain	13.5	10.0	10.8	9.5	8.3	9.9	8.4
<u>Year 2</u>							
Daily Intake, lbs DM							
Hay	16.2	13.8	15.5	15.7	13.2	17.1	12.1
CSM	.9	.9	.9	.9	.9	.9	.9
Molasses		3.0	6.0				
Corn				3.0	6.0		
Soyhulls						3.0	6.0
Total	17.1	17.7	22.4	19.6	20.1	21.0	19.0
Daily gain, lbs	.8	1.0	1.5	1.4	1.7	1.2	1.7
Feed/gain	21.4	17.7	14.9	14.0	11.8	17.5	11.2

Cattle fed the control diet gained approximately 1.0 lb per day (Table 6). This is consistent with results of our other trials where cattle fed ammoniated hay plus 1.0 lb per day of a natural protein source such as soybean meal or cottonseed meal gain approximately 1.0 lb per day. All three energy supplements improved daily gain and feed efficiency compared to the control, and the response to energy level was positive and linear. Animal performance by cattle fed corn and soybean hulls was similar, and both feeds supported greater daily gain than that for molasses.

Liquid Feeds - Dry Feeds

Liquid feeds based on molasses have formed the backbone for supplementation programs for beef cattle in Florida. This will probably hold true for the future, and there are many new developments in liquid feed production including additions of natural proteins, fats and oils, and feed additives such as ionophores. Liquid feeds have advantages over dry feeds in that liquid feeds can be fed from a lick-wheel feeder thereby reducing the bunk space needed for dry feeds. Also, lick-wheel feeders protect the supplement from rain, and liquid supplements generally do not have to be fed with the same frequency as a dry feed.

Because of the negative associative effects on forage digestion that occur when moderate to high levels of feeds such as molasses and corn are fed, by-product feedstuffs such as soybean hulls can be useful where higher levels of supplementation are desired. For example, soybean hulls work well as a supplement for developing heifers to be bred as yearlings. For the past three years we have used soybean hulls as a weaning feed with good success. Soybean hulls feed well from a self-feeder and can be used as a bull feed.

Conclusions

These data suggest that soybean hulls are an excellent energy supplement for beef cattle. Overall, we conclude that soybean hulls have an energy value equal to corn when fed at the levels described above. Overconsumption of soybean hulls by cattle would not be a problem as it would with corn. Incorporation of additional protein, ionophores and minerals/vitamins to soybean hulls to produce a complete supplement seems feasible.

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