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Substitution of Peanut Skins for Soybean Hulls in Steer Finishing Diets Containing Recommended and Elevated Crude Protein Levels[1]

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ABSTRACT: A steer finishing trial was conducted to study the substitution of peanut skins (PS) for soybean hulls (SH) when included at three levels (0, 7.5, or 15%) in diets containing recommended (10.5% = RP) or elevated (15.5% = HP) levels of CP. Average daily gain, DMI, and gain:feed ratios decreased linearly ($P < .01$) when steers were fed RP and increasing levels of PS. Average daily gain and DMI increased linearly ($P < .05$) when steers were fed HP and increasing levels of PS. Carcass quality grades were greater ($P < .05$) for steers fed the HP-15% PS diet than for steers fed either the RP-15% SH or HP-15% SH diets. Ruminal fluid ammonia concentrations were greater ($P < .05$) for HP diets and decreased linearly ($P < .05$) with increasing levels of PS at both RP and HP. Nutrient fractions of the HP diets were more ($P < .05$) digestible for CF, NDF, and ADF than for the RP diets. In general, the HP-7.5% SH/PS diet was more digestible than the other diets in the comparison. When SH are fed as 15% of the diet, PS can be substituted for SH up to 7.5% of the diet at RP levels and can be used to completely replace SH at HP levels.

Key Words: Beef Cattle, Peanut Skins, Soybean Hulls, Protein Supplements

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Introduction

Soybean hulls (**SH**) have successfully replaced some or all of the grain in the diet of dairy (Wagner et al., 1965; MacGregor et al., 1976) and beef cattle (Johnson et al., 1962; Brown et al., 1981; Hibberd and Chase, 1986). Because they are higher in protein and fat and lower in fiber, peanut skins (**PS**) should be a suitable replacement for SH as a feed ingredient in ruminant diets (Hill et al., 1986a, 1987). Approximately 30,000 t of PS are produced annually in the United States as a byproduct of the peanut processing industry. On an as-fed basis, PS contain an average of 17.3% CP and 26.6% ether extract (NAS, 1971). However, PS have been shown to contain 19.6% tannin (McBrayer et al., 1983), which can have a detrimental effect on animal performance. Jung and Fahey (1983) reported that phenolic compounds, such as tannins, bind with enzymes and(or) form nutritionally unavailable polymers with dietary proteins. Hill et al. (1986b) found that increasing dietary CP to 16% in steer finishing diets was effective in overcoming the detrimental effects associated with PS tannins. Therefore, this study was conducted to evaluate PS as a substitute for SH when used in diets containing two levels of CP.

Experimental Procedures

Forty-eight heavy (398 kg) and 48 light (337 kg) crossbred, yearling steers were randomly assigned to pens of eight steers each and were fed one of the six experimental diets shown in Table 1. Fifteen percent PS and(or) SH were included in the diets formulated to contain adequate (10.5%; recommended protein, **RP**) or superadequate (15.5%; high protein, **HP**) levels of CP for large-framed steers gaining 1.4 kg/d (NRC, 1984). Soybean meal was used as the supplemental protein source. The heavy treatment replication of steers was fed for 84 d and the light treatment replication of steers was fed for 126 d. Initial and final weights were taken on each animal after a 15-h, off-water shrink. Individual steer unshrunk weights were obtained at 28-d intervals throughout the study. Total feed consumption by each

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Table 1. Composition of experimental diets[a]

Item	NRC protein (10.5% CP)			High protein (15.5% CP)		
	15% SH	7.5% SH/PS	15% PS	15% SH	7.5% SH/PS	15% PS
Ingredients			% As-fed			
Ground, shelled corn	72.7	73.4	74.2	59.2	60.0	60.7
Peanut hulls	10.0	10.0	10.0	10.0	10.0	10.0
Soybean hulls	15.0	7.5	—	15.0	7.5	—
Peanut skins	—	7.5	15.0	—	7.5	15.0
Soybean meal	1.5	.75	—	15.0	14.25	13.5
Ground limestone	.5	.5	.5	.5	.5	.5
Trace mineral salt	.3	.3	.3	.3	.3	.3
Vitamin A[b]	+	+	+	+	+	+
Nutrient composition			% DM basis			
DM[c]	86.9	87.2	87.2	87.2	87.5	87.7
Ash	3.3	3.3	2.8	3.9	3.9	3.5
Ether extract	3.0	4.1	6.1	3.1	4.7	5.6
Crude fiber	12.3	10.8	9.1	12.9	11.4	11.8
CP	10.9	10.8	10.5	15.5	15.2	15.1
N-free extract	70.5	71.0	71.5	64.6	64.8	64.0
NDF	26.8	24.9	23.3	26.9	24.7	22.4
ADF	15.1	13.9	12.7	16.5	14.8	13.3
ADL	2.9	3.3	3.7	3.3	3.1	3.4
Tannins (tannic acid equivalents)	1.0	2.4	3.8	1.0	2.5	3.9

[a]SH = soybean hulls; PS = peanut skins; NRC = National Research Council recommended CP.
[b]Vitamin A added to each diet at 2,200 IU/kg of feed.
[c]DM expressed on an as-fed basis.

pen was calculated at intervals corresponding to animal weigh days and was used to determine average feed consumption and feed utilization. At the end of the feeding period for each weight replication, the steers were shipped to a local packing company, where they were slaughtered and pertinent carcass data were provided by a certified USDA grader.

Two hours after feeding on d 80 for the heavy steers and d 122 for the light steers, ruminal fluid and fecal grab samples were collected from each steer. Ruminal fluid samples were collected by means of a stomach tube. The pH was determined on the fresh sample. Ammonia concentrations were determined by a direct reading with an ammonia-specific electrode (Orion Research, 1972). Samples were processed according to the procedure of Erwin et al. (1961) and analyzed for VFA by gas chromatography (Baumgardt, 1964). Apparent digestibility of the diets was determined by the lignin ratio technique (ASAS, 1960; Van Soest, 1963). Composite samples of feed offered 5 d before fecal collections were used to characterize the respective diets. Single fecal grab samples were taken per rectum. The CP of feeds and fecal samples was determined using a Kjeltec System (Tecator, Herndon, VA). The ADF and NDF concentrations were determined by the methods of Goering and Van Soest (1970). The ether extract was measured using the Soxtec System HT6 (Tecator). All other analyses of the diets and fecal samples were determined by methods of AOAC (1984).

Data were analyzed as a randomized complete block design with a 2 × 3 factorial arrangement of treatments using the GLM procedure of SAS (1985). Sources of variation were replicate, CP level, PS level, and CP × PS interaction. Treatment × replicate was used as the error term. Treatment responses were partitioned into linear and quadratic effects.

Results and Discussion

Steers in the heavy treatment replication fed for 84 d gained 23% faster ($P < .05$) and consumed a pen average of .67 kg more feed·animal^{-1}·d^{-1} than did steers in the light treatment replication. As a result, animal gain/unit of feed was similar for both heavy and light replications. Carcass data, ruminal fluid characteristics, and digestibility traits were not different due to replication. Therefore, data from the pooled replications were reported in the tables to describe treatment differences.

Average daily gain, DMI, and gain:feed ratios (Table 2) decreased linearly ($P < .05$) when steers were fed RP and increasing levels of PS. The ADG and DMI increased linearly ($P < .05$) when steers were fed HP and increasing levels of PS. The ADG was highest ($P < .05$) for steers fed the high-protein and 15% PS diet (**HP-15% PS**) and lowest ($P < .05$) for steers fed the recommended protein and 15% PS diet (**RP-15% PS**). The ADG for steers fed the other four diets was

Table 2. Means for steer performance and carcass characteristics of steers fed two levels of protein and three levels of peanut skins or soybean hulls[a]

	NRC protein (10.5% CP)[b]				High protein (15.5% CP)				
Item	15% SH[a]	7.5% SH/PS	15% PS	Effect[c]	15% SH	7.5% SH/PS	15% PS	Effect	SE
No. of steers	16	16	16	—	16	15[d]	16	—	—
Initial wt, kg	367	368	368	NS	367	368	368	NS	5.85
ADG, kg	1.42	1.35	.34	L**, Q*	1.26	1.40	1.60	L*	.07
DMI, kg/d	10.1	10.4	8.1	L**, Q*	8.6	9.8	10.7	L*	1.17
Gain/feed	.14	.13	.04	L**, Q*	.15	.14	.15	NS	.07
Carcass data									
Hot carcass wt, kg	299	297	—[e]	L*	295	302	317	L*	6.22
Dressing %	58.3	58.8	—	NS	59.2	59.1	59.7	NS	.41
Marbling score[f]	4.5	4.9	—	NS	4.5	4.7	5.3	NS	.26
Yield grade[g]	2.4	2.6	—	NS	2.3	2.6	2.8	NS	.17
Carcass quality grade[h]	10.8	11.6	—	NS	10.7	11.2	12.4	NS	.44
Longissimus muscle fat, cm	.79	.86	—	NS	.86	.86	1.12	NS	.14

[a]SH = soybean hulls; PS = peanut skins; NRC = National Research Council recommended CP.
[b]Protein level effect for ADG, DMI, and gain/feed ($P < .05$).
[c]L* = linear effect ($P < .05$); L** = linear effect ($P < .01$); Q* = quadratic effect ($P < .05$); NS = nonsignificant ($P > .05$).
[d]One steer died from acidosis after 30 d on feed.
[e]Steers in treatment group were not sufficiently finished to be acceptable slaughter animals.
[f]Marbling scores: 3 = traces; 4 = slight; 5 = small.
[g]Yield grade as specified by USDA where values range from 1 to 5, with values nearer 1 indicating carcasses with a higher percentage of retail cuts.
[h]Quality grade: 10 = average Select; 11 = high Select; 12 = low Choice.

intermediate to that of steers fed these diets. The DMI ranged from 8.1 to 10.7 kg per animal for steers that received the six experimental diets. Approximately three times more ($P < .05$) feed was required per unit of gain for the RP-15% PS Diet than for the other five diets, indicating a negative associative effect.

Steers in both weight replications fed the RP-15% PS diet were not sufficiently finished at the end of the comparison periods and were therefore removed from treatment and not slaughtered. Data for the other five treatments are shown in Table 2. Dressing percentages and longissimus muscle fat measurements were higher ($P < .05$) and yield grades were lower ($P < .05$) for cattle fed the HP-15% PS diet than for those fed the recommended protein and 15% SH (**RP-15% SH**). Carcass quality grades were greater ($P < .05$) for steers fed the HP-15% PS diet than for those fed either the RP-15% SH or HP-15% SH diets. The HP-15% PS treatment group had the highest dietary fat intake, which may have increased fat deposition. McBrayer et al. (1983) fed diets containing 0, 4.8, and 9.1% PS and reported increased carcass fat and carcass quality grades for steers fed diets containing PS.

Ruminal fluid pH, molar percentages of VFA, and NH_3 concentrations are shown in Table 3. In general, steers fed RP-15% PS exhibited higher molar proportions of acetic acid, lower propionic and butyric acids, and higher acetic:propionic acid ratios than did steers fed the other diets. Total VFA (micromoles/milliliter) concentration of ruminal fluid was greatest ($P < .05$) for steers fed the HP-7.5% SH/PS diet and lowest ($P < .05$) for steers fed the RP-15% PS diet. The lower VFA concentration for steers fed the RP-15% PS diet indicates a reduced level of microbial activity and corresponds to reduced performance observed for cattle fed the RP-15% PS diet. Ruminal fluid NH_3 concentrations were greater ($P < .05$) for the HP diets than for the RP diets. Increasing the level of PS in both the RP and HP diets resulted in a linear ($P < .05$) decrease in ruminal fluid NH_3 concentrations. Several factors may have been responsible for the poor animal performance when the RP-15% PS diet was fed. The 3.6 mg/dL of ruminal fluid NH_3 measured for steers fed RP-15% PS was possibly not sufficient to support ruminal microbial activity or the PS tannins may have had a toxic effect on the ruminal microflora. Haaland et al. (1982) reported that increasing dietary protein levels from 11 to 17% resulted in increased ruminal N_3 and VFA concentrations. However, tannins have been shown to inhibit fermentation in the rumen (Kendall, 1966; Jung and Fahey, 1983) and thereby alter ruminal metabolism. Kumar and Singh (1984) concluded that dietary tannins adversely affect ruminal metabolism through inhibition of digestive enzyme systems, proteolysis, and microbial synthesis.

The apparent digestibilities (Table 4) of crude fiber, NDF, and ADF were greater ($P < .05$) for steers fed HP diets than for those fed RP diets. Tyrrell and Moe (1980) reported that increased dietary protein content increased DM digestibility. Poos et al. (1979) and Hill et al. (1986a) demonstrated that the digestibility of low-protein diets was improved by adding urea or soybean meal to the diets. Digestibility of the ether extract fractions was highest ($P < .05$) for

Table 3. Ruminal fluid characteristics of steers fed two levels of protein and three levels of peanut skins or soybean hulls[a]

	NRC protein (10.5% CP)[b]				High protein (15.5% CP)				
Item	15'% SH[a]	7.5% SH/PS	15% PS	Effect[c]	15% SH	7.5% SH/PS	15% PS	Effect	SE
VFA, % of total									
C_2 (acetic)	45.4	44.7	52.2	NS	44.0	47.3	49.1	NS	3.04
C_3 (propionic)	37.4	40.6	26.8	Q*	37.0	39.3	36.2	NS	2.40
C_4 (butyric)	12.5	10.8	18.0	NS	14.0	10.2	12.0	NS	2.03
C_{5i} (isovaleric)	.3	.8	.6	NS	1.4	.5	.9	NS	.25
C_5 (valeric)	4.3	3.2	2.5	NS	3.6	2.7	1.7	NS	.72
C_2:C_3 ratio	1.3	1.4	2.2	NS	1.3	1.3	1.7	NS	.24
Total VFA, μmol/mL	115.6	138.1	85.5	NS	163.1	174.8	129.3	NS	26.00
pH	5.6	6.3	6.6	NS	5.8	5.9	6.3	NS	.13
NH_3, mg/dL	5.3	3.9	3.6	L*	11.9	9.5	5.8	L*	.74

[a]SH = soybean hulls; PS = peanut skins; NRC = National Research Council recommended CP.
[b]Protein level effect for C_{5i} and NH_3 ($P < .05$).
[c]L* = linear effect ($P < .05$); Q* = quadratic effect ($P < .05$); NS = nonsignificant ($P > .05$).

the HP-7.5% SH/PS diet, intermediate for the RP-7.5% SH/PS diets, and lowest for the RP-15% SH and HP-15% SH diets. Peanut skins contain 26% ether extract, compared with 2% ether extract for SH, which contributed to increased ether extract content of diets containing PS. Greater ether extract digestibility was reported by Hill et al. (1986a) when PS were added to the diet of steers and by Johnson et al. (1988) when peanut hearts were added to the diet of lactating dairy cows. Palmquist and Conrad (1978) concluded that increasing the level of dietary fat dilutes the metabolic fecal fat and improves apparent ether extract digestibility.

Regardless of dietary protein level, the DM and NDF fractions were more ($P < .05$) digestible for diets containing 7.5% SH/PS than for diets containing 15% SH or 15% PS. This quadratic response ($P < .05$) was also observed for ether extract, N-free extract, and NDF for steers fed the HP diets. There was an apparent positive associative effect between PS and SH. However, the associative effect detected in this study is confounded by the increased tannin content of the 15% PS diets, as evident by the quadratic response to levels of PS and SH.

Implications

Peanut skins are generally priced considerably lower than soybean hulls. Because peanut skins are higher in crude protein and fat and are similar to soybean hulls in terms of physical characteristics, it would be desirable to substitute peanut skins for soybean hulls in cattle diets. The results of our study

Table 4. Apparent nutrient digestibility of diets containing two levels of protein and three levels of peanut skins or soybean hulls[a]

	NRC protein (10.5% CP)[b]				High protein (15.5% CP)				
Apparent digestibility	15% SH[a]	7.5% SH/PS	15% PS	Effect[c]	15% SH	7.5% SH/PS	15% PS	Effect	SE
	%								
DM	66.7	67.9	58.3	Q*	71.5	80.4	74.5	L*Q**	1.50
CP	58.4	51.5	23.5	NS	67.9	76.9	60.5	NS	5.25
Crude fiber	18.7	25.6	19.1	NS	31.5	46.9	54.8	L*	2.87
Ether extract	62.3	74.7	77.3	NS	61.3	90.8	82.2	Q*	5.52
N-free extract	77.9	77.3	67.1	NS	81.4	87.4	82.4	Q*	1.72
NDF	29.2	35.9	21.3	Q*	43.5	53.2	49.1	Q*	3.84
ADF	15.6	23.0	17.9	NS	31.9[c]	43.1	39.5	L*	2.85

[a]SH = soybean hulls; PS = peanut skin; NRC = National Research Council recommended CP.
[b]Protein level effect for CP, NDF, and ADF ($P < .05$).
[c]L* = linear effect ($P < .05$); Q* = quadratic effect ($P < .05$); Q** = quadratic effect ($P < .01$; NS = nonsignificant ($P > .05$).

show that peanut skins can be used to replace one-half (7.5%) of the soybean hulls in a steer finishing diet containing 15% soybean hulls. If the dietary crude protein level is increased to 15.5%, peanut skins can be used to replace all of the soybean hulls in a diet containing 15% soybean hulls.

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