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Effects of Distillers Dried Grains with Solubles on Feed Intake, Growth Performance, Gain Efficiency and Carcass Quality of Growing Kiko x Spanish Male Goats

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Abstract: Objectives were to evaluate, the effects of Distillers Dried Grains with Solubles (DDGS) on feed intake, growth, gain efficiency, selected blood metabolites and carcass quality of growing Kiko x Spanish intact male kids. Twenty-four male goats (28.9±1.28 kg BW and 4-5 months of age) were stratified by weight and randomly assigned to diets containing 48.4% Bermudagrass Hay (BGH) and 51.6% concentrate mix containing 0, 10.3, 20.6 and 31.0% of DDGS on a DM basis (6 goats diet^{-1}). Feed intake was monitored daily. Body weight was monitored every 4 weeks and blood samples were collected at the start and end of the trial. After 57 days, goats were harvested and carcass characteristics were determined. Feed intake, average daily gain, gain efficiency, selected blood metabolites and carcass data were analyzed as a completely randomized block design. Initial BW ($p = 0.22$), final BW ($p = 0.39$), Average Daily Gain (ADG; $p = 0.62$), DM intake ($p = 0.62$) and Gain to Feed ratio (G:F; $p = 0.84$) were not different among treatments. There were no effects of DDGS on plasma urea nitrogen ($p = 0.17$). Serum cholesterol concentrations increased linearly ($p<0.001$) with increasing levels of DDGS. Dressing percent ($p = 0.18$) and rib eye area ($p = 0.73$) remained similar. Body wall fat ($p = 0.45$) and longissisimus muscle area ($p = 0.73$) values were unaffected. Results indicated that DDGS is a viable feedstuff for meat goats and up to 31% of DDGS can be included in the diet on a DM basis for growing goats without any compromise in DM intake, growth performance and carcass quality.

Key words: Goats, DDGS, intake, growth, gain efficiency, carcass quality

INTRODUCTION

The increased availability of Distillers Dried Grains with Solubles (DDGS), a co-product of fuel ethanol industry, mainly from corn, has created both challenges as well as opportunities for the livestock industry. The DDGS can provide relatively high levels of protein, energy, highly digestible fiber and minerals. According to Ham *et al*. (1994), DDGS also contains a significant amount of rumen undegradable protein (approximately, 55% of crude protein), which could replace animal by products for the source of bypass proteins. Traditionally, DDGS has been fed to ruminants especially cattle. Experiments evaluating the use of DDGS in dairy (Schingoethe, 2004), beef cattle (Corners and William, 2002), swine (Shurson *et al*., 2004) and poultry (Lumpkins *et al*., 2005) are reported. Of the portions of DDGS used for domestic livestock feeding, 55% is used by beef cattle, 21% by dairy and 6% each by the pig and poultry industries (McVey *et al*., 2005). With the expansion of the ethanol industry in the US, DDGS could be freely available and relatively inexpensive relative to other feedstuffs that are commonly used in goat diets. However, there is very limited research that evaluated the use of DDGS in goat diets.

Objectives of the current study were to determine the effects of various dietary inclusion rates of DDGS on DM intake, growth performance, gain efficiency and carcass quality of growing Kiko x Spanish male goats.

MATERIALS AND METHODS

Experimental animals: The study was conducted at the Tuskegee University George Washington Carver Agricultural Experiment Station, Tuskegee, Alabama, USA. Goats were purchased from a local producer. Upon arrival, goats were deformed with Cydectin (moxidectin; Fort Dodge Animal Health, Fort Dodge, IA, USA) and vaccinated with *Clostridium perfringens* type C and D-Tetani Bacterin-Toxoid (Bayer Corp., Shawnee Mission, KS, USA). Twenty-four Kiko cross-bred intact male goats (28.9±1.28 kg initial BW and 4-5 months of age) were

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individually housed in 1.1×1.2 m pens with plastic-coated expanded metal floors. The study was conducted in compliance with the Tuskegee University Institutional Animal Care and Use Committee regulations.

Experimental diets and methods: The concentrate mixes containing DDGS were formulated to be isonitrogenous at 16% crude protein. The DDGS (Poet Nutrition, Dakota Gold, Sioux Fall, SD) replaced corn and soybean meal in the concentrate mixes and comprised 0, 10.3, 20.6 and 31% of diet DM. The goats were offered 50% hay (Bermudagrass Hay; BGH) and 50% concentrate mix (as-fed basis) separately. The basal diet was formulated to meet or exceed all nutrient requirements of growing goat kids (NRC, 2007). The nutrient compositions of DDGS, BGH and concentrate mixes are shown in Table 1 and 2. Feed was offered once daily at 16:00 h throughout the study period and intake was adjusted weekly to allow an excess of 5% of their anticipated intakes on an as fed basis. Animals had access to water freely. The hay was chopped to 5-10 cm in length for ease of handling.

Body weights were recorded every 4 weeks after a 4 h withdrawal of feed and water. The initial and final body weights were used to calculate average daily gains. The daily feed intake was monitored throughout the feeding period and gain efficiency was calculated by dividing ADG by average DMI.

Collection of blood samples: Blood samples were collected in vacationer tubes at the beginning and end of 57 days feeding period by jugular venipuncture. Blood samples were placed on ice immediately after collection and transported to the laboratory for further preparation. Serum samples were collected from clotted blood samples by centrifuging at 1,800× g at 5°C for 30 min. Plasma and serum samples were frozen at -20°C, until they were analyzed for blood metabolites. Plasma urea N was analyzed using an auto analyzer (Brian and Luebbe, Analyzing Technologies, Elmsford, NY, USA). Serum cholesterol concentrations were analyzed according to the method described by Sigma (1995). Plasma samples were analyzed for concentration of glucose by direct measurement using the YSI model 2700 SELECT Biochemistry Analyzer (Yellow Springs Instrument Co., Inc., Yellow Springs, OH, USA).

Chemical analysis: Composite samples of hay, concentrate mixes and also DDGS were analyzed for DM, Ether Extract (EE), CP (Kjeldahl N×6.25) and ash (AOAC, 1990). The Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined using methods outlined by Van Soest *et al.* (1991) and modified (Komarek, 1995) for use in an Ankom fiber apparatus (Ankom Technology Corp., Fairport, NY, USA). Hemicellulose was calculated as the difference between NDF and ADF.

Table 1: Chemical composition of hay and Distillers Dried Grain Solubles (DDGS) used in the experiment[a]

Items	Hay	DDGS
Dry matter (%)	88.28	87.84
Crude protein (%)	10.28	28.73
Acid detergent fiber (%)	34.90	12.00
Neutral detergent fiber (%)	69.32	27.79
Ether extract (%)	2.10	11.93
Total digestible nutrients (%)	48.81	90.34
Net energy for gain (Mcal kg^{-1})	0.37	1.57
Lignin (%)	4.71	1.10
Ash (%)	5.85	4.81
Phosphorus (%)	0.24	0.90
Sulfur (%)	0.28	0.89

[a]All values except DM are on DM basis

Table 2: Ingredient and chemical composition of different concentrate mixes containing different levels of Distillers Dried Grain Solubles (DDGS)

	DDGS (%)			
Items[a]	0	10.3	20.6	31.0
Ingredient composition of concentrate mixes (as is basis %)				
Cracked corn	73.6	62.3	50.8	33.0
Soybean meal (48% CP)	19.4	10.7	2.2	-
DDGS	-	20.0	40.0	60.0
Molasses (Black strap)	5.0	5.0	5.0	5.0
Goat premix[b]	2.0	2.0	2.0	2.0
Chemical composition (dry matter basis %)				
Dry matter	88.35	89.35	89.69	89.95
Crude protein	13.58	16.79	15.33	16.44
Ether extract	3.09	4.14	5.02	6.18
Non-fiber carbohydrate	68.93	65.00	64.21	60.23
Neutral detergent fiber	10.80	10.07	12.06	13.75
Acid detergent fiber	2.95	3.36	3.79	4.37
Hemicellulose	7.85	6.71	8.27	9.38
Ash	3.30	3.71	3.41	3.49
Phosphorus	0.45	0.52	0.49	0.58
Sulfur	0.16	0.25	0.27	0.35

[a]All vales are on dry matter basis except dry matter. [b]Goat premix contained: (%) Ca 9.0, P 8.0, Salt 41.0, K 0.10, Mg 1.0; (ppm) Cu 1,750, Se 25.0, Zn 7,500 and (IU kg^{-1}) Vitamin A 308,644, Vitamin D 24,251 and Vitamin E 1,653

Carcass characteristics: Goats were harvested at the end of 57 days of feeding period. The harvesting and sampling were done according to the USDA standards at the Lambert-Powell Meats Laboratory, Auburn University, Auburn, AL, USA. Hot Carcass Weights (HCW) were taken after slaughter and measurements on the carcasses were obtained after 24 h postmortem chill. The dressing percent was calculated by dividing HCW by live BW. The Longissimus Muscle (LMA) cross-sectional area and Body Wall Fat (BWF) were determined by a certified USDA grader 48 h after slaughter.

Statistical analysis: Feed intake, average daily gain, gain efficiency, selected blood metabolites and carcass data were analyzed using the GLM procedure of SAS (1998) as a randomized complete block design. The initial BW was used as a covariate for ADG, DMI, gain to feed ratio, blood urea nitrogen, glucose and cholesterol and carcass data. The effects of varying levels of DDGS were tested by a polynomial regression using orthogonal contrast for equally spaced treatments (Steel *et al.*, 1997). The differences among means were detected at $p<0.05$ level of significance.

RESULTS AND DISCUSSION

Diet composition: The chemical composition of hay and DDGS are shown in Table 1, while the ingredient and chemical composition of concentrate mixes are given in Table 2. The different amounts of DDGS in the diet resulted in different concentration of EE in the concentrate mixes as expected. One of the concerns with DDGS is nutrient variability as with any other co-product (Shurson *et al.*, 2004). Kononoff and Christensen (2007) reported that the CP content of DDGS ranged from 26.6-33.9%, EE from 10-15.9%, NDF from 28.6-38.4%, phosphorus from 0.77-1.06 and sulfur from 0.46-0.83%. In the current study, the nutrient contents of the DDGS used were within the lower reported range.

Although, efforts were made to maintain diets of goats to a 50:50 ratio of hay to concentrate for each diet, actual intake ratios were different. The hay to concentrate ratios for the 0, 10.3, 20.6 and 31.0% DDGS diets were 49.1:50.9, 48.2:51.8, 48.0:52.0 and 48.2:51.8, respectively. The overall hay to concentrate ratio was 48.4:51.6, which was closer to the ratio intended.

Dry matter intake: No signs of acidosis, bloat, or urinary calculi were observed with any dietary treatments and no apparent palatability problems associated with feeding DDGS were noted. The DMI reported as g day^{-1} was not different ($p = 0.62$) among treatments (Table 3), when goats were fed 0, 10.3, 20.6 and 31.0% DDGS on a DM basis. There were no apparent palatability problems with DDGS in the diet. The concentrate mix and hay intakes were also similar ($p = 0.50$ and 0.73, respectively) among treatments. The 31% DDGS diet resulted in 4.22% fat in the diet DM, but the level of fat provided by DDGS inclusion was not high enough to depress DMI. When the concentration of fat exceeds 7-9% of the diet DM, the DM intake is depressed in goats (Morand-Fehr, 2005).

Intake data for goats on DDGS diets are not available; therefore, comparisons are based on other livestock species. Results of the current study agree with sheep data reported by Huls *et al.* (2006), who found no difference in DMI, ADG, G:F and carcass characteristics in finishing lamb wethers fed DDGS, which replaced a portion of corn and soybean meal (22.9% of the diet DM) in the diet. Similarly, Kleinschmidt *et al.* (2006) found no difference in DMI with 20% DDGS in the diet of dairy cows, but milk production was higher in cows fed diets containing DDGS. In contrast, Hippen *et al.* (2003) evaluated the effects of replacing 10, 20, 30, or 40% soybean meal, soybean hulls and animal fat in the Holstein dairy cows' diet with Wet Distillers Grains (WDG) and observed that increasing WDG above 20% of DM decreased DMI and yields of milk and milk components. Although, they used wet distiller's grains, the feeding value of dry and wet dried distillers has been found to be similar according to Al-Suwaiegh *et al.* (2002), who reported that lactating dairy cows fed wet and dried distillers at 15% of the diet DM had similar DMI, milk production and milk composition.

Growth performance and gain efficiency: Average daily gains averaged 141, 134, 115 and 117 g day^{-1} for the diets containing 0,10.3, 20.6 and 31.0% DDGS, respectively (Table 3). The corresponding values for gain efficiency expressed as ADG/DMI (G:F) were 0.12, 0.12, 0.11 and 0.12, respectively. There were no differences among treatments in ADG and G:F ratios. Initial BW and final BW also were not different among diets. The mean ADG of goats in the current study were comparable to values reported by other researchers. Waldron *et al.* (1995) reported 132 g day^{-1} ADG for Spanish goat kids (approximately, 4-8 months of age) consuming an 80%

Table 3: Average daily gain and dry matter intake of Kiko x Spanish crossbred growing male goat kids fed different amount of Distillers Dried Grain Solubles (DDGS)

	DDGS (DM%)			
Items	0	10.3	20.6	31.0
Initial BW (kg)	27.9±0.94	29.8±0.73	27.8±0.82	29.5±0.73
Final BW (kg)	38.5±1.63	39.8±1.26	36.4±1.42	38.3±1.26
ADG (g day^{-1})	141±18.4	134±14.2	115±16.0	117±14.22
Total DMI (g day^{-1})	1.017±87.3	1.138±77.5	1.106±93.1	1,003±87.0
Concentrate mix (g day^{-1})	519±41.9	591±37.2	575±44.7	520±41.8
Hay (g day^{-1})	499±45.8	547±40.7	531±48.5	483±45.7
G:F ratio (ADG/DMI)	0.12±0.013	0.12±0.010	0.11±0.010	0.12±0.010

Table 4: Blood metabolites and carcass characteristics of growing Kiko x Spanish crossbred growing male goat kids fed different amounts of Distillers Dried Grain Solubles (DDGS)

	DDGS (DM%)				
Items[a]	0	10.3	20.6	31.0	p-value[a]
BUN (mg dL^{-1})	19.0±2.240	25.0±1.830	20.0±2.030	20.7±1.830	0.17
Cholesterol (mg dL^{-1})	41.2±7.930	66.2±6.500	76.5±7.200	83.2±6.490	0.01
Glucose (mg dL^{-1})	53.8±5.690	62.3±5.050	69.5±6.070	68.4±5.670	0.25
Body wall fat (cm)	0.94±0.10	1.09±0.08	0.91±0.10	0.97±0.08	0.45
Rib eye area (LMA) (cm^2)	9.75±1.15	10.25±0.88	9.50±1.03	9.00±0.90	0.73
Dressing (%)	44.6±1.230	45.1±0.950	44.7±1.070	42.2±0.950	0.18

[a]Linear effects based on orthogonal contrast for equally spaced treatments. The quadratic and cubic effects were not significant

concentrate diets. The values for Kiko crossbred intact males were not available for comparison. Cameron *et al.* (2001) found ADG of 154, 161 and 117 g day^{-1} for Boer x Spanish, Boer x Angora and Spanish wethers fed high-concentrate diets *ad libitum* (CP 25%) during a 16 weeks period after weaning whereas, the G:F values were 0.263, 0.235 and 0.261, respectively. The gain efficiency reported by Cameron *et al.* (2001) was higher than the current values, which could be explained by differences in genotypes used, age of experimental animals and the plane of nutrition between the two studies.

Serum metabolites: No differences were observed among treatments in the initial and final BUN concentrations (Table 4). The BUN values, although not statistically different among treatments, were numerically higher for diets with higher DDGS inclusion rates compared to the control diet. The concentrations also increased numerically as goats grew old. The final BUN concentrations were 19.0, 25.0, 20.0 and 20.8 mg dL^{-1} for diets containing 0, 10.3, 20.6 and 31% DDGS, respectively. This is in agreement with results from Horn and Beeson (1969), who observed no difference in BUN concentration in steers when, 5% DDGS was added to the basal diet at the expense of cracked corn and urea. Swenson (1977) also did not detect any difference in BUN concentrations in goats because of dietary treatments in goats. The current values were within the normal range for goats (Swenson, 1977) and gives no indication of problems with using DDGS in the feeding program. In contrast, heifers fed the 20% DDG diets had higher BUN values than heifers receiving the diets with 10% DDG (Vander Pol *et al*., 2005). In addition, they reported that heifers on all treatments had increased BUN values with time, as observed in the current trial. The BUN concentrations may be useful as an indicator of protein status within a group of animals and could help to fine-tune diets or identify problems with a feeding program (Kohn *et al*., 2005). Also, the BUN concentration has been shown to be related to energy intake and balance of protein and energy in diets (Hagemeister *et al*., 1981).

The serum cholesterol concentration at the start of the trial was not different among treatments, but at the end of the study, it increased linearly ($p<0.001$) as dietary amounts of DDGS increased in the diet. However, these values were, within normal ranges for goats (55-200 mg dL^{-1}) (Swenson, 1977). Feeding fat to dairy cows almost always increases plasma cholesterol and the increase is independent of the degree of fatty acid saturation (Grummer and Carroll, 1991). The increased serum cholesterol levels in high DDGS-containing diets can be attributed to higher levels of fat in the diets due to DDGS inclusion.

The blood glucose levels were not different among treatments, but were within normal range for goats (Swenson, 1977). Feeding more ruminally degradable starch has been shown to increase plasma glucose concentrations in dairy cows (Santos *et al*., 2000) because of the greater output of glucose by the liver (Theurer *et al*., 1999). In the current study, the higher levels of DDGS replaced higher levels of corn in diets resulting in less starch available for rumen degradation, but the effect was not reflected by increased glucose values.

Carcass characteristics: There were no differences in Body Wall Fat (BWF) thicknesses among treatments (Table 4). The values were 0.94, 1.09, 0.91 and 0.97 cm for diets containing 0, 10.3, 20.6 and 31.0% DDGS, respectively. The results were in agreement with those of Solaiman *et al.* (2006), who reported the BWF thickness of 0.81 cm for Boer x Spanish wether goats fed a high concentrate diet (70%) consisting of corn and soybean meal. The BWF values in the current experiment compared favorably with the values reported by Oman *et al*. (1999) for feedlot feeding regimen. According to Oman *et al.* (1999), the BWF values were 1.32 and 1.4 cm for Boer x Spanish and Spanish male kids in feedlot condition, respectively. In their study, the corresponding values for range feeding regimens were 0.62 and 0.53 cm, respectively.

The LM area values averaged 9.8, 10.3, 9.5 and 9.0 cm^2 for diets containing 0, 10.3, 20.6 and 31.0% DDGS, respectively and were not affected by dietary treatments. Similar to our results, Cameron *et al.* (2001) reported

11.6, 10.2 and 10.2 cm^2 for Boer x Spanish, Spanish and Boer x Angora, respectively, when fed a concentrate-based diet and goats were slaughtered at 212 days of age and similar (10.2 cm^2) to those reported by Solaiman *et al.* (2006) for Boer x Spanish wether goats fed a high-concentrate diet.

The Dressing Percentages (DP) were 44.6, 45.1, 44.7 and 42.2% for goats on diets containing 0, 10.3, 20.6 and 31.0% DDGS, respectively. Although, not significantly different, the DP decreased numerically as DDGS level increased in the diets. The dressing percentages observed in the current study were lower than that reported by Oman *et al.* (1999). They found the average DP of 57.2% in 9 months old Boer x Spanish, Spanish and Spanish x Angora males fed diets with 80% concentrate (12.5 or 15% CP), *ad libitum* whereas, those on the range type feeding regimen had DP of 48.2%.

The higher DP reported by Oman *et al.* (1999) could be due to higher plane of nutrition and due to different genotypes compared to the current study. The dressing percent is affected by age (Laor, 1978), castration (Owen and Norman, 1977), breed of the goat and plane of nutrition (Devendra and Burns, 1983). The values reported by Cameron *et al.* (2001) were comparable to the current study, who found 46.3, 47.3 and 47% DP for Boer x Spanish, Spanish and Boer x Angora wethers, respectively, when consuming a concentrate-based diet and slaughtered at 212 days of age. In addition, DP can be lower depending of the extent of carcass trimmings, or presence or absence of kidneys when hot carcass weights are measured. The kidneys were not included as a part of the carcass weight in the present study.

CONCLUSION

The results of this study indicate that DDGS can completely replace soybean meal and a portion of corn in the supplement and up to 31% of the diet DM when feeding growing meat goats. The lack of detectable differences among treatments may be attributed to not using sufficiently high level of DDGS. Therefore, further studies are required to determine the maximum level of DDGS that can be included in diets for growing goats. Also effects of DDGS on goat meat quality traits and sensory attributes must be evaluated for consumer acceptability. However, the use of DDGS as an alternative feed supplement for goats depends on relative prices of DDGS, corn and protein supplements.

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