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RESEARCH ARTICLE

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Effects of Corn Stover Particle Size on Growth Performance, Feeding Behavior and Nutrients Digestibility in Beetal Bucks

F. Majeed[1], S. Ahmed[1], M.A. Rashid[1], M.Q. Shahid[2]

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ABSTRACT

Background: The optimization of particle size of corn stover is necessary before it is being added in goat ration as it affects the uniformity and structural effectiveness of the diet, feed intake and digestion process in goats.

Methods: A total of 24 bucks (10±1 months old; body weight of 20±1 kg) were selected and divided into three treatment groups of 8 bucks in each group in a Completely Randomized Design. Dietary treatments included conventional total mixed ration containing corn stover of three different particle sizes: 1) 8 mm;) CS8; 2) 16 mm, CS16 and 3) 24 mm, CS24. The experiment lasted for 15 weeks including 02 weeks of adaptability period.

Result: The results indicated that particle size of corn stover significantly affected average daily gain (ADG) by bucks. The ADG was highest in the CS8 group. The bucks in the CS8 spent less time eating but numerically had higher dry matter intake.

Key words: Average daily gain, Bucks, Corn stover, Digestibility, Feeding behaviour, Particle size.

INTRODUCTION

Livestock is an important compartment of rural economy of Pakistan as this sector is a direct source of income generation for more than 70% of the rural population (Shahid *et al*. 2019). This sector contributes significantly to the economy of Pakistan it has a share of about 60.1% in agricultural GDP and 11.5% in overall GDP of the country (Pakistan Economic Survey, 2020). Sheep and goat, among different livestock species, provide mutton, milk and wool and are considered as an income generating source for small and marginal farmers (Ishaque and Haq, 2007).

The area for fodder cultivation is decreasing gradually due to sharp rise in human population, rapid urbanization and expansion of cereal crop land (Tesfaye and Chairatanayuth, 2007). Crop residues, are fibrous plant parts; including leaves, stubble, stalk and root that remain in the field after harvesting (Islam *et al*. 2020). Currently among different cereal crop residues, corn stover (CS), has gained much importance for its utilization in livestock feed. Pakistan produces 43 MMT of crop residues annually in which the part of CS is about 1.5 MMT (Akram and Firincioglu, 2019).

The CS biomass is comprised of cellulose, hemicellulose, ash and lignin (Schittenhelm, 2010). Corn stover has variable carbohydrate contents depending on variety, stage of plant maturity, crop density and drought stress (Mourtzinis *et al*. 2016). The intake of diet containing corn stover as crop residue by the livestock species depend on various factors including energy level of the diet, digestibility and particle size of roughage (Kendall *et al*. 2009).

Various crop residues differ from each other in terms of their physical characteristics including particle size (PS) and thus affect the production performance of livestock (Nagi *et al*. 2012). The optimization of PS of crop residues is, therefore, necessary before being added in ration as it affects uniformity and structural effectiveness of the diet, feed intake and digestion process in the ruminants. Several techniques including chopping and grinding were developed to reduce the PS of crop residues (Tafaj *et al*. 2007). This PS reduction has resulted in an improved voluntary intake of crop residues and thus, better production performance in goats (Banerjee, 2000). In the current study, it was hypothesized that smaller CS particle size may exert positive effects on growth performance in bucks.

[1]Department of Animal Nutrition, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan.
[2]Department of Livestock Management, University of Veterinary and Animal Sciences, Lahore, Pakistan.

Corresponding Author: S. Ahmed, Department of Animal Nutrition, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan.
Email: saeed.ahmed@uvas.edu.pk

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MATERIALS AND METHODS

Research procedures were in accordance with the instructions permitted by Animal Care and Use Committee, University of Veterinary and Animal Sciences Lahore (UVAS). An experiment was conducted at the Small Ruminant Research and Training Center (SRTC), UVAS, Ravi Campus, Pattoki, Pakistan. Overall 24 animals (10±1 months old; body weight of 20±1 kg) were selected. The selected animals were divided into three treatment groups of 8 bucks in each group in a completely randomized design.

Dietary treatments included conventional total mixed ration (TMR) containing CS having three different particle sizes: 1) 8 mm, CS8; 2) 16 mm, CS16; and 3) 24 mm, CS24. TMR was prepared by mixing the required quantities of CS and concentrate ingredients. All the diets were isocaloric and isonitrogenous in nature with a forage to concentrate ratio of about 75:25, respectively and were formulated as per the nutrient requirements suggested by National Research Council (NRC, 2007) as presented in Table 1. The bucks were fed twice a day at 06:00 and 18:00 h throughout the study. The study lasted for 15 weeks, which included 2 weeks of adaptation, 12 weeks of data collection and 1 week for conducting digestibility experiment.

Behavioural activities of the bucks were recorded for 24 hours at d 14, 28 and 56 of the experimental study with the help of video camera (DAHUA HFW 3449 T1, China) mounted in the station. The parameters noted included feeding time bouts, its length, lying time bouts its length, rumination bouts and total rumination time in sitting and standing position. For digestibility measurement, intake of feed and output of fecal material were recorded from each animal on daily basis for five consecutive days. Nutrient digestibility of each experimental diet was calculated by using the following formula (Blanco *et al.* 2014). The digestibility of nutrients were also determined by using above mentioned formula.

$$\text{Digestibility (\%)} = 100 \times \frac{\text{Dietary intake (of the nutrient) - Facial output of the nutrient}}{\text{Dietary intake}}$$

Rumen liquid was collected, four hours after morning feeding, at day 1, 28 and 56 of the trial by using oral tube. The collected rumen liquor was immediately filtered with the help of four layered cheese cloth for pH determination (Starter 3100, OHAUS and Parsippany, NJ, USA). Fecal scoring was performed on regular basis from 1 to 10 weeks by using 1 to 5 fecal scoring system with 1 for normal pellets and 5 for watery feces (Jamber *et al.* 2007).

The diets were separated according to particle size by using Penn State Particle Separator of 3 mm screen which, in turn, distributed the particles into four different portions comprising long (19 mm), medium (8 mm), short (1.18 mm) and fine (1mm). Feed sorting activity was, then, determined by calculating actual DMI expressed as percentage of predicted DMI, for each fraction. Physical effectiveness factor of the ration was measured as the amount of particles recollected on 19 and 8 mm screen of Penn State Particle Separator, whereas physically effective NDF was determined by multiplying physically effective factor with NDF contents of the ration Leonardi and Armentano, (2003). Values above 100% indicated better feed consumption, whereas below 100 indicated selective consumption. If the value was equal to 100%, it indicated no sorting of feed (Overvest *et al.* 2016).

The blood samples were examined for phosphorous (Altair™ 240, Lab compare, South San Francisco, CA, USA) plasma urea nitrogen (PUN, 21516 © Biosystems and Barcelona, Spain), plasma glucose (GLUCOSE, 23503 © Biosystems, Barcelona, Spain), calcium (CA 0305 CH, Chema diagnostic), bilirubin (GP F 400 CS, SPHERA, Italy).

Table 1: Ingredient composition and nutrient analysed composition of the experimental diets.

Ingredients %	Inclusion %
Corn stover	25.0
Wheat bran	28.0
Corn grain	14.0
Canola meal	8.0
Soybean meal	12.0
Molasses	10.50
Mineral mixture	2.0
Sodium bicarbonate	0.5
Analyzed nutrient composition (on DM basis)	
DM % (as such)	82.25
CP %	15.0
ME mcal/kg	2.4
NDF %	32
Calcium %	0.73
Phosphorus %	0.52

Statistical analysis

Data were analysed by one-way ANOVA method using SAS operating system (version 9.1). The following statistical model was used;

$$Yij = \mu + ES\ i + e_{ij}$$

Where,
Yij = Dependent variable.
μ = Mean of the population.
ES i = Role of different particle size of CS.
e_{ij} = Residual effect.

RESULTS AND DISCUSSION

Growth performance, fecal scoring and pH of rumen

Particle size significantly affected growth performance (Table 2). The average daily gain was higher (123.2 g/d) in CS8 group compared to the CS16 and CS24 groups (98.9 and 90.3 g/d, respectively. The rumen pH was lower in CS8 group (6.55) compared to the CS24 (6.64; P=0.03. Dry matter intake and fecal score were similar among all the treatment groups (P>0.05). The higher ADG in the bucks fed fine PS may possible due to an increase in surface area for fermentation of straw. Similar observation were also recorded by Soita, (2000) who reported that rumen function of cow was improved by reducing particle size of silage. No effect of CS particle size on DMI observed in current study was in line with those reported by Al-Saiady *et al.* (2010) and Zhao *et al*. (2009). Similarly, Leonardi *et al*. (2003) also had reported no significant effects of CS particle size on DMI in the bucks. The improved ruminal pH by the increase of crop residue particle size in the present study is in accordance with the discoveries of Zhao *et al*. (2009).

Behavioral characteristics

Table 3 represents the influence of CS size on behavioral characteristics in Beetal bucks. The total feeding time was higher (209 min/d) in CS24 group compared to the CS8 (145 min/d; SE =7.16; P = 0.01). Both the CS16 and CS24 has similar feeding time. The feeding bout length was higher (19.3 min/bout) in CS24 group compared to the CS8 and CS16 groups (12.9 and 14.9 min/bout, respectively; SE=0.55; P=0.01). Total rumination time was higher (10.4 h/d) in CS24 group compared to the CS8 and CS16 groups (8.6 and 8.7 h/d, respectively. The other behavioral parameters including total feeding bouts, total lying time and lying bout length as well as duration were similar among the treatment groups. The detected higher feeding and rumination time and level of each feeding bout in the present study is in accordance with that reported in small ruminants (Zhao *et al.* 2009; Schultz *et al.* 2019). These studies reported an increased feeding and rumination time and duration of each feeding bout in the bucks fed large particle size CS based ration.

Nutrient digestibility and blood metabolites

The results of blood metabolites and nutrient digestibility are presented in Table 4 and Table 5 respectively. The DM digestibility tended to be higher (73.1%) in CS8 group

Table 2: Effects of different particle sizes of corn stover on growth performance, rumen pH and fecal score in Beetal bucks.

Parameters	Treatments[1]			SEM[2]	P-value
	CS8	CS16	CS24		
DMI[3] (g/day)	640.6	633.8	613.9	30.1	0.93
IBW[4] (g)	20.58	20.59	20.45	0.22	0.84
ADG[5] (g/day)	123.2[a]	98.9[b]	90.3[b]	3.46	0.01
AWG[6] (kg)	7.76[a]	6.23[b]	5.94[b]	0.20	0.01
Rumen pH	6.55[b]	6.60[ab]	6.64[a]	0.01	0.03
Fecal score	1.04	1.05	1.03	0.07	0.48

a-b Means without a common superscript within a column significantly (P<0.05) differ.

[1]WS= Corn stover particle sizes, [2]SEM= Standard error mean, [3]DMI= Dry matter intake, [4]IBW= Initial body weight, [5]ADG= Average daily gain, [6]AWG= Average weigh.

Table 3: Effects of different particle sizes of corn stover on behavioral characteristics in Beetal bucks.

Parameters[1]	Treatments[2]			SEM[3]	*P* - value
	CS8	CS16	CS24		
FT (minutes/day)	145[b]	187[a]	209[a]	7.16	0.01
FB (number/day)	7.3	7.8	7.5	0.25	0.67
FBL (minutes/bout)	12.9[b]	14.9[b]	19.3[a]	0.55	0.01
LT (minutes/day)	678	677	728	19.12	0.45
LL (minutes/day)	66	71	71	2.37	0.61
LB (number/day)	7.5	7.4	7.8	0.24	0.80
RBS (minutes/day)	3.16	3.58	3.00	0.13	0.20
RBL (minutes/day)	5.50[b]	5.37[b]	7.25[a]	0.26	0.04
TRT (h/day)	8.6[b]	8.7[b]	10.4[a]	0.26	0.02

a-b Means without a common superscript within a column significantly (P<0.05) differ.

[1]FT= Feeding time, FB= Feeding bouts, FBL= Feeding bout length, LT= Lying time, LL= Lying bout length,

LB= Lying bouts, RBS= Rumination bouts standing, RBL= Ruminating bouts lying, TR = Total ruminating time. [2]Corn stover particle sizes[3], SEM= Standard error mean.

Table 4: Effects of different particle sizes of corn stover on blood metabolites in Beetal bucks.

parameters	Treatments[1]			SEM[2]	P-value
	CS8	CS16	CS24		
Glucose (mg/dl)	56.93	54.68	54.00	0.82	0.31
Calcium (mg/100ml)	8.98	8.94	8.88	0.73	0.87
Phosphorous (mg/100ml)	12.08	12.85	12.95	0.40	0.64
Urea (mg/dl)	50.25	50.65	47.75	0.69	0.18
Bilirubin (mg/dl)	0.41	0.42	0.41	0.07	0.86

[2]SEM= Standard error mean. [a-d] Means without a common superscript within a column significantly (P<0.05) differ. [1]WS= Corn stover particle sizes.

Table 5: Effects of different particle sizes of corn stover on nutrient digestibility in Beetal bucks.

Digestibility (%)[1]	Treatments[2]			SEM[3]	P-value
	8 mm	16 mm	24 mm		
DM	73.09	72.67	72.56	0.48	0.06
OM	77.25	77.10	77.05	0.06	0.43
CP	70.31	70.18	70.12	0.04	0.15
NDF	65.32	65.20	65.15	0.05	0.11
ADF	61.24[c]	61.68[b]	62.13[a]	1.01	0.01

[a-d] Means without a common superscript within a column significantly (P<0.05) differ.

[1]DM= Dry matter, OM= Organic matter, CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber.

[2]Corn stover particle sizes.

[3]SEM= Standard error mean.

[1]WS= Corn stover particle sizes, [2]SEM= Standard error mean.

Table 6: Effects of different particle sizes of corn stover on blood parameters in Beetal bucks.

parameters	Treatments[1]			SEM[2]	P-value
	CS8	CS16	CS24		
Glucose (mg/dl)	56.93	54.68	54.00	0.82	0.31
Calcium (mg/100 ml)	8.98	8.94	8.88	0.73	0.87
Phosphorous (mg/100 ml)	12.08	12.85	12.95	0.40	0.64
Urea (mg/dl)	50.25	50.65	47.75	0.69	0.18
Bilirubin (mg/dl)	0.41	0.42	0.41	0.07	0.86

1DM= Dry matter, OM= Organic matter, CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, [2]Corn stover particle sizes, [3]SEM= Standard error mean.

Table 7: Effects of different particle sizes of corn stover on feed sorting behaviour in Beetal bucks.

Items	Treatments[1]			SEM[2]	P-value
	CS8	CS16	CS24		
Sorting of particle fraction (%)					
>19 mm	87.60	88.00	90.80	1.09	0.43
8-19 mm	100.35	100.30	98.35	0.41	0.07
<8 mm	101.45	100.30	101.15	0.27	0.22
Pan	102.60	102.30	102.35	0.28	0.90
PeNDF[3]	96.60	97.20	97.75	0.40	0.10

[1]Corn stover particle sizes, [2]SEM= Standard error mean, [3]PeNDF= Physically effective neutral detergent fiber contents.

compared to the C16 and C24 (72.7 and 72.6%, respectively. Similar to the present findings, Hamed and Elimam, (2009) documented enhanced digestibility of DM, CP, OM and NDF in the animals fed diets containing small particle size sorghum stover based ration. The digestibility of nutrients in small particle size based TMR is due to increase in surface area that enhanced digestibility (Maulfair *et al.* 2011).

Plasma levels of glucose, calcium, phosphorous, urea and bilirubin were similar among all the treatment groups (P>0.05; Table 6). The present findings about serum levels of glucose, blood urea nitrogen and bilirubin are consistent with the previous literature in the small ruminants (Wang *et al.* 2011; Malik *et al*. 2020). Concurring with the current findings, Bhandari *et al.* (2007) found no significant effects of CS particle size on hematological parameters in the bucks.

Feed sorting behaviour

The influence of CS particle size on behavior of feed sorting in the Beetal bucks is presented in Table 7. The results showed no significant effects of different particle sizes of the CS on feed sorting behavior of Beetal bucks. The present findings regarding the distribution of different particle fractions on Penn state separator are in line with those reported by Al-Saiady *et al*, (2010) and Yang and Beauchemin, (2005). These authors reported no significant effects of CS particle size on various fractions of pen state and physically effective NDF in the bucks.

CONCLUSION

The overall findings of the study indicates higher average weight gain, decreased ruminal pH and reduced feeding and rumination time by the inclusion of 8mm particle size corn stover in the ration of bucks. Corn stover particle size, however, it did not affect nutrient digestibility, hematological profile and feeding behavior in the bucks. Further experimental studies are required, to investigate the effects of various particle sizes of different crop residues on different production parameters in ruminants.

Conflict of interest: None.

REFERENCES

Akram, M.Z. and Firincioglu, S.Y. (2019). The use of agricultural crop residues as alternatives to conventional feedstuffs for ruminants: A review. Eurpean Journal of Agriculture Research. 3(2): 58-66.

Al-Saiady, M.Y., Abouheif, M.A., Aziz Makkawi, A., Ibrahim, H.A. and Al-Owaimer, A.N. (2010). Impact of particle length of alfalfa hay in the diet of growing lambs on performance, digestion and carcass characteristics. Asian-Aust. J. Anim. Sci. 23: 475-482.

Banerjee, G.C. (2000). Feed and Principles of Animal Nutrition, 2nd rev. ed. Oxford and IBH Publishing Company, India. p. 13.

Bhandari, S.K., Ominski, K.H., Wittenberg, K.M., Plaizier, J.C. (2007). Effects of chop length of alfalfa and corn silage on milk production and rumen fermentation of dairy cows. Journal of Dairy Science. 90. 2355-2366.

Blanco, C., Bodas, R., Prieto, N. andres, S., Lopez, S. Giraldez, F.J. (2014). Concentrate plus ground barley straw pellets can replace conventional feeding systems for light fattening lambs. Small Ruminants Research. 116: 137-143.

Hamed, A.H.M. and Elimam, M.E. (2009). Effects of chopping on utilization of sorghum stover by Nubian goats. Pakistan Journal of Nutrition. 8(10): 1567-1569.

Ishaq, M. and Haq, Z.U. (2007). Small ruminants farming in Pakistan. Annals of Arid Zone. 46(3): 379-386.

Islam, M.S., Hashem, M.A., Islam, S., Alam, M.H., Rahim, M.A., Akterruzzaman, M. (2020). Utilization of crop residues in rural household of Bangladesh. Progressive Agriculture. 31(3): 164-177.

Kendall, C., Leonardi, C., Hoffman, P.C. and Combs, D.K. (2009). Intake and milk production of cows fed diets that differed in dietary neutral detergent fiber and neutral detergent fiber digestibility. Journal of Dairy Science. 92: 313-323.

Le, J.L., Dominik, S., Eady, S., Henshall, J., Colditz, I. (2007). Adjusting worm egg counts for faecal moisture in sheep. Veterinary Parasitology. 145: 108-115.

Leonardi, C. and Armentano, L.E. (2003). Effect of quantity, quality and length of alfalfa hay on selective consumption by dairy cows. Journal of Dairy Science. 86: 557-564.

Malik, M.I., Rashid, M.A., Yousaf, M.S., Naveed, S., Javed, K., Rehman, H. (2020). Effect of physical form and level of wheat straw inclusion on growth performance and blood metabolites of fattening goat. Animals. 10: 1-11.

Mourtzinis, S., Cantrell, K.B., Arriaga, F.J., Balkcom, K.S., Novak, J.M., Frederick, J.R. Karlen, D.L. (2016). Carbo hydrate and nutrient composition of corn stover from three south eastern USA locations. Biomass and Bioenergy. 85: 153-158.

Maulfair, D.D., Fustini ,M., Heinrichs, A.J. (2011) Effect of varying total mixed ration particle size on rumen digesta and fecal particle size and digestibility in lactating dairy cows. Journal of Dairy Science. 94: 3527-3536.

Nagi, P.R.S., Reddy, D.N., Nagalakshmi, D., Reddy, Y.R., Raghunandan, T. (2012). Effect of particle size of paddy straw on physical characteristics and performance of lambs fed paddy straw based complete diets. Animal Nutrition and Feed Technology. 12: 111-119.

NRC. (2007). Nutrient Requirements of Small Ruminants: sheep, Goats (2007). Cervids and New world Camelids; The National Academies Press: Washington, DC, USA. p. 384.

Overvest, M.A., Bergeron, R., Haley, D.B., DeVries, T.J. (2016). Effect of feed type and method of presentation on feeding behavior, intake and growth of dairy calves fed a high level of milk. Journal of Dairy Science. 99(1): 317-327.

Pakistan Economic Survey. (2020-21). Government of Pakistan, Ministry of Food and Agriculture, Economic Adviser's Wing, Islamabad, Pakistan. pp. 37.

Schittenhelm, S. (2010). Effect of drought stress on yield and quality of maize/sunflower and maize/sorghum in-tercrops for biogas production. Journal of Agronomy and Crop Science. 196: 253-261.

Schultz, E.B., Amaral, R.M.D., Gloria, L.S., Silva, F.F., Rodrigues, M.T., Vieira, R.A.M. (2019). Ingestive behavior of dairy goats fed diets containing increasing levels of neutral detergent fiber and particle size using multivariate analysis. Acta Scientiarum Animal Sciences. 19: 1-8.

Shahid, M., Shah, M., Kiani, A.Parveen, F. (2019). Development of livestock and productivity of labour in Pakistan: An empirical work. Sarhad Journal of Agriculture. 35(2): 647-653.

Soita, H.W., Christensen, D.A., McKinnon, J.J. (2000). Influence of particle size on the effectiveness of the fiber in barley silage. Journal of Dairy Science. 83: 2295-2300.

Tafaj, M., Zebeli, Q., Baes, C.H., Steingass, H. Drochner, W. (2007). A meta-analysis examining effects of particle size of total mixed rations on intake, rumen digestion and milk production in high yielding dairy cows in early lactation. Animal Feed Science and Technology. 138: 137-161.

Tesfaye, A., Chairatanayuth, P. (2007). Management and Feeding Systems of Crop Residues: The experience of East Shoa Zone, Ethiopia. Livestock Research and Rural Development. 19, 31.

Wang, M., Zhao, X.G., Liao, H.Y., Tan, Z.L., Tang, S.X., Sun, Z.H., Zhou, C.S. Han, X.F. (2011). Effects of rice straw particle size on digesta particle size distribution, nitrogen metabolism, blood biochemical parameters, microbial amino acid composition and intestinal amino acid digestibility in goats. Animal Science Journal. 82: 78-85.

Yang, W.Z. and Beauchemin, K.A. (2005). Effects of physically effective fiber on digestion and milk production by dairy cows fed diets based on corn silage. Journal of Dairy Science. 88: 1090-1098.

Zhao, X.G., Wang, M., Tan, Z.L., Tang, S.X., Sun, Z.H., Zhou, C.S., Han, X.F. (2009). Effects of rice straw particle size on chewing activity, feed intake, rumen fermentation and digestion in goats. Asian-Aust J. Anim Sci. 22: 1256-1266.