Research Article

Effect of Replacing Soybean Meal with Corn Steep Liquor on Growth Performance and Blood Metabolites in Beetal Goats

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Abstract | The objective of present study was to evaluate the effect of replacing soybean meal with corn steep liquor on dry matter intake (DMI), growth performance and blood metabolites in Beetal bucks. Twenty-four Beetal bucks of age 12 ± 1 months having body weight of 30 ± 5kg were selected and divided into three treatment groups, having eight animals in each, under completely randomized design. Treatment 1) had no corn steep liquor while treatment 2) and 3) contained 10% and 20% corn steep liquor as a partially replacement of soybean meal respectively. Dry matter intake was significantly (p≤0.05) higher (1223g/day) in 3rd treatment and average daily gain was also significant (p≤0.05) higher in 3rd treatment treatments (123.53g/day) as compared to 2nd and 1st treatment group (102.6, 93.7g/day) respectively. Blood glucose level (58.8mg/dl) and blood urea nitrogen (20.7mg/dl) were increased in 3rd treatment as compared to other treatment groups. However, there was no difference in body measurements of all treatments. In conclusion, soybean meal can successfully be replaced with corn steep liquor without any deleterious effect on growth performance and economically better as compared to soybean meal.

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Introduction

Goats are important component of livestock that are playing an important role in the economy of Pakistan. There are around 37 goat breeds in Pakistan (Bhutto *et al.*, 1993; Isani and Baloch, 1996). Beetal goat has six strains found in different regions of Punjab Faisalabadi strain present in Faisalabad, Sahiwal, Okara Lahore, Sheikhupura, Makhi Cheeni strain is found in Bahawalpur, Bahawalnagar, Muzaffargarh, Nuqri strain is found in Dera Ghazi khan and Rajanpur, Gujrati strain is found in Gujrat, Sargodha, Jhelum, Nagri strain is found in Faisalabad, Okara, Sahiwal and Ry khan strain is available

in Rahim Yar khan and mixed in Faisalabad and Pakpattan districts (Khan and Okeyo, 2016). One of most popular breeds in the subcontinent is the Beetal goat. They serve numerous functions, for a variety of reasons; they are the most popular goat breed of subcontinent. The first reason they are preferred by farmers is that they produce high quality meat that can be sold at very good price in the market. In the country, 40% red meat comes from small ruminants (Khan *et al*., 2004). According to economic Survey of Pakistan 2023-24 mutton production was recorded at 613,000 tons against the set targets of 817,000 tons. In the production of high-quality meat, animal feed has an important role. Furthermore, market prices for protein sources used in animal feed are quite expensive. Management and nutrition are regarded as the most significant variables in determining meat production quality, quantity and economic efficiency (Agnihotri *et al*., 2006). Feeding contributes up to 70% of cost in the animal production (Rodrigues and Rondina, 2013). In order to compete in the market, animal production should follow nutritional practices which are economically feasible. Two important components of animal diet are protein and energy, that they play a key part in their growth production (Tauqir *et al*., 2011).

Soybean meal, which is widely used across the world, is the primary protein source in animal diets (Jelali and Salem, 2014). However, the cost of animal production is increased because soybean meal is too expensive. To address this issue, researchers using alternative feeds to investigate the consequences of using soybean meal as a partial replacement in diets (Irshaid *et al*., 2003; Haddad, 2006; Silva *et al*., 2016). Industrial by-products with high protein content have the potential to be used as ruminant nutrition feedstuff (Kazemi-Bonchenari *et al*., 2017). Industrial processing of maize grain produces a variety of by- products; such as corn gluten meal, corn steep liquor (CSL).

CSL is produced when cleaned corn is transported to steeps and warm water with temperature 125F to 130F is circulated in steeps with small quantities of dissolved sulfur dioxide for 40 hours. Sulfurous acid is formed by the reaction of sulfur dioxide with water that control fermentation and assist in the separation of starch and protein, during this process soluble component are extracted from kernel and this liquid is passed through evaporators for some time and then CSL is formed. CSL is byproduct of the maize milling industry's wet milling process and contains up to 40% crude protein. Carbohydrates, essential amino acids, peptides, organic compounds, magnesium, phosphate, calcium, potassium, sulfur, and chloride are all abundant in the CSL (Sarwar and Khan, 2004). It is composed of 50% dry matter (DM) and10% Ash (Sarwar and Khan, 2004). CSL being a source of Non-Protein Nitrogen contain 30% of corn nitrogen, in the form of ammonia nitrogen and amino nitrogen, contain unidentified growth factor that enhance weight gain in animals as compared to soybean meal (Liggett and Koffler, 1948).

Corn steep liquor contains 21% lactic acid and has a pH of 3.7 (Khan *et al*., 2004). Therefore, corn steep liquor might be a good protein source in animal production system. It possesses pelleting qualities and increases feed palatability (Gupta *et al*., 1990; Talpada *et al*., 1987; Wagner, 1982). Increasing the price of soybean meal affecting negatively farm profitability, corn steep liquor has some easily fermentable carbohydrate which produce keto acids on hydrolysis and ruminal ammonia nitrogen combined with keto acids that improve rumen microbial proliferation and enhance feed digestion, moreover one of major reason to replace it with soybean meal due to high prices of soybean meal as compared to corn steep liquor, thus there is a need to find economical protein source that could improve farm profitability and improve bucks feed intake and weight gain. Hence objective of this study was to evaluate the influence of replacing soybean meal with corn steep liquor on feed intake, growth performance and blood metabolites in Beetal goats.

Materials and Methods

Experimental station

The present study was performed at the Small Ruminant Research and Training Center, University of Veterinary and Animal Sciences Lahore, (UVAS) Ravi Campus Pattoki, Pakistan. The average temperature during the study was 28°C and humidity was 44% according to weather conditions from google.

Experimental design

All the experimental procedures were approved by Ethical Review Committee, University of Veterinary and Animal Science, Lahore, Pakistan vide letter no (DR-170; 2022). Experimental duration was 60 days excluding 14 days of adaptation period. Twenty-four

Beetal bucks, of age 12±1months having average body weight 30±5 kg, were selected and divided into three treatment groups under completely randomized design (CRD). Three total mixed rations having isonitrogenous and isocaloric composition were formulated and offered to each treatment group as shown in Table 1. Treatment 1 is control (having no CSL), treatment 2 and 3 containing diet as partially soybean meal substitute protein content with CSL at the rate of 10% and 20% respectively. Feed was calculated according to guidelines based on NRC (2007). Feed was offered *ad-libitum* twice a day at 6.00AM and 6.00PM in individual pens. Feed allowance was adjusted to allow 10% orts on daily basis. Comparative composition of soybean meal and corn steep liquor is presented in Table 2.

Parameters evaluated

Dry matter intake (DMI) On the basis of dry matter intake, feed intake was calculated. The following formula was used to calculate DMI: Feed intake (kg) =Feed offered (kg) - Feed refused (kg) (Suyitman *et al.*, 2020). Dietary sample was analyzed for dry matter according to the AOAC method (AOAC 2005). Average daily gain (ADG): On a weekly basis, the average daily gain was calculated by using the formula below:

ADG= final BW-Initial BW/duration of experimental period (El-Emam *et al.*, 2018).

Blood sampling: At the start and end of trial five animals from each group were selected for blood sampling. Blood was collected from jugular vein puncture in a tube containing EDTA and centrifuged at 3000rpm for 15minutes and stored at -20C for further analysis. The blood glucose and blood urea nitrogen (BUN) were analyzed in university diagnostic laboratory (UDL) using commercially available kits (El-Emam *et al.*, 2018).

Body condition score: The body condition score was measured at the start and end of trial using 1.0 to 5.0 with scoring system.BCS-1 is emaciated, BCS-2 is thin, BCS-3 is average, BCS-4 is fat and BCS-5 is obese, for BCS fat was observed on transverse process of lumbar vertebrae, fat on ribcage and also check fat on sternum (Ghosh *et al.*, 2019).

Body measurements: Body measurements including withers height were measured from highest point over scapula to vertical ground, heart girth from smallest circumferences just behind the foreleg and body length was measured from point of shoulder to pin bone on weekly basis (Iqbal *et al.*, 2013).

Feed efficiency: following formula was used to calculate the feed efficiency.

Feed efficiency = Average daily gain (kg)/feed intake (kg) (Hu *et al.*, 2012).

As the economics was calculated as output to input ratio data in this study, showing that there is a high return in 20% CSL group as compared to control due to high price of soybean meal as compared to corn steep liquor (Gomaa and Badawy, 2018).

Table 1: *Ingredients and chemical composition of TMR on DM basis.*

Ingredients	Control	CSL10%	CSL20 %
Oat silage	45.0	45.0	45.0
Corn grain	25.0	25.0	25.0
Soybean meal	20.0	17.8	15.6
CSL	_	2.2	4.4
Molasses	8.0	8.0	8.0
Mineral mixture	1.0	1.0	1.0
Soda bicarb	1.0	1.0	1.0
Total	100	100	100
DM%	60.68	60.0	59.33
CP%	15.87	15.78	15.69
Energy Mcal/kg	2.56	2.55	2.54
NDF	30.10	30.83	31.56
NFC	49.64	49.24	48.84
Ca	0.76	0.76	0.75
P	0.36	0.39	0.41

Control = corn steep liquor 0%, CSL 10% = corn steep liquor 10%, CSL 20% = corn steep liquor 20%.

Table 2: *Comparative Composition of SBM and corn steep liquor.*

Nutrients soybean meal	Corn steep liquor
Dry matter % 89.7	50
Protein % 43-44	40
Ash % 8	10
pH -	3.7-21
Lactic acid % -ANF trypsin inhibitor	Nill

ANF= anti-nutritional factor.

Statistical analysis

Data were analysed by repeated measure ANOVA

using the GLM procedures of SAS (version 9.1). Data for weight gain and total feed intake were analysed by one-way ANOVA (Steel *et al.*, 1997). Results were declared statistically significant at p ≤ 0.05 and trend at p≤0.10 than the means of significant results were compared by Tukey's HSD post Hoc multiple comparison tests.

Results

If p value is less than 0.05 (p≤0.05) the results were significantly higher and if the p value is greater than 0.05 (p≥0.05) results are not significantly higher as shown in my results. With regard to dry matter intake is significantly higher (p≤0.05) in CSL20 (1223.42g/day) as compared to control (1169.93g/day) and CSL10 (1202.46g/day). Average daily gain is also significantly higher (p≤0.05) in CSL 20 (123g/day) while in CSL10 and control ADG is 102g/day and 93g/day, respectively as shown in Table 3. The results of body condition score are non-significant among three treatment groups but numerically better (p = 0.110) in animals fed CSL containing diet as compared to control. Body condition score is directly related to weight gain so in this study weight gain was higher in CSL containing diet fed to bucks as presented in Table 3.

Table 3: *Growth performance, blood metabolites and body measurements of Beetal goats among different treatment groups.*

Parameter	0%CSL	10%CSL	20%CSL	p-value
DMI (g/day)	1169.93 ^{c}	1202.46 ^{b}	1223.42 ^{a}	0.000
ADG (g/kg)	93.71 ^{c}	102.46 ^{b}	123.53 ^{a}	0.001
BCS	1.43	1.59	1.88	0.110
Blood glucose	53.3	49.2	58.8	0.232
BUN	20.7	25.7	23.5	0.065
Feed efficiency	0.068	0.075	0.078	0.783
heart girth (inch)	0.12	0.00	0.37	0.177
Economics (input/output)	0.88	1.02	1.10	0.563

Superscripts on different means within row differ significantly at p ≤ 0.05. DMI = dry matter intake; ADG = average daily gain; BCS = body.

Blood metabolites including blood glucose and blood urea nitrogen increased numerically (p=0.232) in animals fed ration containing 20% CSL, respectively (58.8mg/dl) and BUN (p= 0.065) is (23.5mg/dl) as compared to other treatments. Feed efficiency was numerically better (p= 0.783) in ration containing 20% CSL as compared to other treatments. No change in body measurements except heart girth that was slightly changed as it has direct relationship with body. CSL as the economics was calculated as output to input ratio data in this study, showing that there is a high return in 20% CSL group as compared to control due to high price of soybean meal as compared to corn steep liquor containing diet was economically better (p= 0.563) as compared to diet of control treatment (Table 3).

Discussion

Dry matter intake was higher in CSL20 as compared to control and CSL10 and can be attributed to improvement in ruminal fermentation because CSL provides minerals, amino acids and peptides that will lead to improved ruminal fermentation. CSL being a source of amino acids, peptides and soluble carbohydrates might have improved fermentation in rumen rapidly as compared to diets without CSL. Some fermentable carbohydrate presents in CSL that produce keto acids after hydrolysis. Keto acids combine with ruminal ammonia nitrogen due to which it might be possible to improve carbon and nitrogen synchronization in the rumen leading to enhanced microbial proliferation to improve the digestion of feed (Sarwar *et al.*, 1991). CSL is high in nutrients that not only enhance microbial synthesis but also improve microbial efficiency that will link to dry matter intake (Haddad and Goussous, 2005). Feed intake increased in this study because ingestion of nutrient like dry matter in rumen has an important role in controlling of feed intake (Baile and Forbes, 1974). In rumen, rate of microbial degradation helps in the emptying of rumen which is also helpful in controlling the passage rate of feed ingested (Mertens, 1977). Feed intake increased in this study because feed intake also depends on palatability of feed and CSL has increases feed palatability (Gupta *et al.*, 1990). Feed intake in this study was increased due to pelleting characteristics of CSL, as we found when CSL was fed with different variety of grains, (Jiriaei *et al.*, 2020). Average daily gain was higher in CSL 20% treatment as compared to control because improved weight gain in bucks feeding CSL diets was due to increase in DMI and CSL contain unidentified growth factor that enhances weight gain in bucks. CSL has different micro and macro nutrients that might have influenced the ecology of rumen that led to VFA production due to which flow of microbial

amino acids to intestine and increased average daily gain which may be attributed to improved ruminal fermentation (Sarwar *et al*., 2004). Results of our study are in line with Mirza and Mushtaq (2006) who reported that 5%CSL is useful for growth and feed: gain ratio. These results are also in line with the findings of Kaviani *et al*. (2022) who reported that average daily gain was highest when soybean meal was replaced with CSL at the rate of 0%, 25%, 50% and 100% in lambs.

Feed efficiency was numerically better in CSL containing diet. CSL being a source of nitrogen and yields keto acids on hydrolysis that cause the synchrony of carbon and nitrogen utilization for microbial proliferation that will lead to improved feed degradation (Sarwar *et al*., 1991). CSL has different micro and macro nutrients that might have influenced the ecology of rumen that will lead to VFA production due to which flow of microbial amino acids to intestine has increased average daily gain which may be attributed to improved ruminal fermentation (Sarwar and Khan, 2004). Improved ruminal fermentation resulting in improved digestion that's why efficiency of feed utilization was improved. Feed efficiency is indexing that reflecting the digestion and absorption of diet. Diet containing CSL might increase the activity of ruminal microbes including fermentation, digestion and absorption which results in better growth and feed efficiency. These results are in line with the findings of (Gomma and Badwy, 2018) who reported that CSL at the level of 0%, 10%, 20% and 30% was used in male goat kids, the efficiency of feed utilization was better in ration contained CSL when fed to male goat kids than in ration without CSL.

Body condition score is non-significant but numerically better in animals fed CSL containing diet as compared to control. Body condition score is directly related to weight gain so in this study weight gain was higher in CSL containing diets fed to bucks. Body condition score is increased in animals having CSL in their diet because increased dry matter intake that improved growth performance ultimately improved body condition score of animals as also reported by Wagner *et al*. (1983).

Blood glucose concentration was increased in bucks fed CSL20% diet might be attributed to the efficient fermentative activities by rumen microbes which might have ensured increased plasma glucose concentration, it is an indicator of energy status of animal and a function of intake level that supply more energy to the metabolism in the animal body (Reynolds *et al*., 2003). The increased blood urea-N concentration in bucks fed CSL was in association with higher ruminal ammonia-N in them because there is positive correlation in ruminal ammonia-N and blood urea-N as reported by Azizi-shotorkhoft *et al*. (2013). As the economics was calculated as output to input ratio data in this study, showing that there is a high return in 20% CSL group as compared to control due to high price of soybean meal as compared to corn steep liquor. These results are in line with the findings of Nisa *et al*. (2004) reported that CSL is consider as a major by-product of corn starch processing and can be utilized as an inexpensive source of nitrogen, vitamins, amino acids, peptides and soluble nutrients. Recently Saba *et al*. (2015) concluded that replacing concentrate feed mixture with CSL at rates 10, 20 or 30 % on the basis of crude protein in the diets could improve economic efficiency and increase the productive performance of goats and their offspring.

Conclusions

From the results of present study, bucks fed CSL 20% diet improved feed intake, growth performance and economically better as compared to soybean meal. Therefore, it is concluded that CSL 20% can be replaced with soybean meal in the diet of Beetal bucks without any adverse effect.

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Novelty Statement

The use of CSL in partial replacement of soybean meal in the diets of Beetal bucks is not studied yet in Pakistan.

Author's Contribution

Muhammad Usman, Saeed Ahmed, Muhammad

Shahbaz Zafar and Imran Mohsin: Design and plan of experiment were planned and developed.
Muhammad Usman and Saeed Ahmed: Prepared research material and methods.
Mohsin Ali and Muhammad Noman Tariq: Collected data.
Saeed Ahmed, Muhammad Shahbaz Zafar and Imran Mohsin: Helped in result interpretation.
Muhammad Usman, Saeed Ahmed, Ghulam Qadir and Sohail Ahmad: Manuscript reviewed and edited.

Data availability
Data will be available on demand.

Ethics approval
All experimental procedure was approved by (ACUC) Animal Care and Use Committee University of Veterinary and animal Sciences UVAS Lahore, Pakistan vide letter no. 170.

Conflict of interest
The authors have declared no conflict of interest.

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