JAPSC

Journal of Animal and Poultry Sciences, 2015, 4 (3): 39-48

Available online at http://www.JAPSC.com

Influence of Varying Levels of Corn Steep Liquor on Nutrients Intake, Digestibility and Growth Response in Growing Buffalo Calves

M. SHAHBAZ QAMAR*[1], M. UN-NISA[2] , M. SARWAR[3] and Z. UR-RAHMAN[4]

[1]*Institute of Animal Sciences, University of Agriculture, Faisalabad, Pakistan*
[2]*Institute of Home and Food Sciences, Government College University, Faisalabad, Pakistan*
[3]*Faculty of Animal Husbandry, University of Agriculture, Faisalabad, Pakistan*
[4]*Institute of Pharmacy, Physiology and Pharmacology, University of Agriculture, Faisalabad, Pakistan*

Abstract

This study was planned to examine the influence of varying levels of corn steep liquor on feed intake and growth performance of growing nili-ravi male buffalo calves. Fifty male buffalo calves of 9 month old were randomly divided into five groups, 10 animals in each group, using Randomized Complete Block Design. Five isonitogenous (16% crude protein) and isocaloric (2.6 Mcal/kg) diets were formulated. The control diet had 0% corn steep liquor and in 20, 40, 60 and 80% diets, urea on nitrogen equivalent was replaced by corn steep liquor, respectively.Animals were given weighed amount of feed twice daily at ad libitum. The daily feed offered and refusals were recorded to calculate dry matter intake. The sample of feed offered and refusal were used to determine dry matter, crude protein, neutral detergent fiber and acid detergent fiber. Animals fed 40% corn steep liquor diets ate highest dry matter (3.33kg daily)and was the lowest (3.16 daily) by those fed 40% corn steep liquor diets. The neutral detergent fiber and acid detergent fiber digestibility was higherin animals fed diets containing corn steep liquor than those fed diet containing 0% level. However, dry matter and crude protein digestibility remained unaltered across all diets. Calves fed 40% corn steep liquor diets gained more weight (757 g/day) than those fed 80% (637 g/day). Pre slaughter weight of animals fed 40% corn steep liquor diet was the highest (141.5 kg) and was the lowest (130 kg) in those fed 80% corn steep liquor diet. Warm carcass weight was higher in animals fed 40% (65.8 kg) diet followed by those fed 60%, 80%, 20% and control diets. Primal cuts, ash, Na, K and Ca remained unchanged across all diets. The red blood cell count, white blood cells, packed cell volume and hemoglobin values were also same across all diets. In conclusion, animals fed CSL40 diet gained more weight and were cost-effective when compared to those fed control, 20%, 60% and 80% diets.

Key words: Buffalo Calves, Corn Steep Liquor, Intake, Digestibility, Growth Performance.

***Corresponding author: Tel: +923007601848
E-mail address: mshahbazqamar@gmail.com

Introduction

Increasing prices of feed ingredients are making livestock keeping unaffordable by the resource poor livestock farming community of the country. This farming community is maintaining more than 80% of country's livestock (Sarwar et al., 2004). This increased feed ingredient cost coupled with a feed shortage has not only worsened feed availability, but it has also adversely affected profitable livestock production. This situation reduces animals performance which are already under fed (Sarwar et al., 2004b). This feed shortage situation can be improved through many ways but addition of new feed ingredients in the national feed inventory after the determination of their nutritional value seems promising.

Many agro industrial byproducts, including molasses, rice polishings, wheat bran, sugarcane pith, oil cakes and meals, hulls, corn industry byproducts etc., have already been added. Their inclusion in feed formulation has not only enhanced animal productivity but it has also improved feed value (Khan et al., 2004) and reduced animal feeding cost (Sindhu et al., 2002), because more than 70% cost of any livestock enterprise is incurred on feed (Nisa et al., 2004). Thus, exploring new feedstuffs, their chemical and biological evaluation for livestock will open new avenues to reduce the feed shortage.

One of the byproducts of corn industry is corn steep liquor (CSL) which may offer a promising protein alternate (Nisa et al., 2004b) provided nutritionally evaluated. It is a byproduct of wet corn milling industry and is high (40%) in crude protein (CP). The CSL is a good source of carbohydrates, essential amino acids, peptides, organic compounds, magnesium, phosphorous, calcium, potassium, chloride, sodium, sulfur and myo-inositol phosphates (Nisa et al., 2004; Hull et al., 1996). It contains 50% dry matter (DM), 10% ash and 16% nitrogen free extract (NFE). Its pH is 3.7 and it contains 21% lactic acid (Khan et al., 2008). It is high in K which limited its inclusion in ruminant feed (Andrew and Tom, 2013) because K is bitter in taste that reduces feed consumption when high levels of CSL are used (Andrew and Tom, 2013). However, the scientific evidence regarding the influence of feeding high level of dietary CSL on feed intake, digestibility, weight gain and meat quality in ruminants is limited. Therefore, present study was planned to evaluate the effect of CSL on nutrients intake and their digestibility, weight gain, hematology and carcass quality of growing male buffalo calves.

Materials and Methods

Animals and Diets

In this experiment, fifty male buffalo calves of 9 months old were randomly divided into five groups, 10 animals in each group, using Randomized Complete Block Design based on their weight. Five isonitogenous (16% CP) and isocaloric (2.6 Mcal/kg) diets were formulated. The control diet (C) had 0% CSL and in CSL20, CSL40, CSL60 and CSL80 diets, 20, 40, 60 and 80% urea on nitrogen equivalent was replaced by CSL, respectively (Table 1).

Table 1. Ingredients and chemical composition of experimental diets

Ingredients (%)	Diets[1]				
	C	CSL20	CSL40	CSL60	CSL80
Wheat Straw	15.0	14.0	17.0	33.5	33.0
Corn Grains	35.0	20.0	20.0	15.0	5.0
Urea	4.0	3.0	2.0	1.0	0.0
[2]CSL	0.0	5.0	10.0	15.0	20.0
Canola Meal	0.0	0.0	3.0	4.5	6.0
Sunflower Meal	0.0	0.0	3.0	4.5	6.0
Corn Glutten 60%	0.0	0.0	2.5	4.5	5.5
Rice Polishings	24.0	28.0	15.0	4.0	4.0
Maize Bran	15.0	26.0	10.0	4.0	3.0
Enzose	3.0	0.0	13.5	10.0	13.5
$NaHCO_3$	1.0	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0	1.0
[3]DCP	2.0	2.0	2.0	2.0	2.0
Chemical Composition (%)					
Dry Matter	91	90.1	89.9	89.8	88.8
Crude Protein	19	19	19.1	19.1	19.1
Neutral Detergent Fiber	23.0	26.5	23.4	34.7	34.2
Acid Detergent Fiber	13.5	14.6	14.7	23.5	23.6
Metabolizable Energy; ME (Mcal/kg)	2.6	2.6	2.6	2.6	2.6

[1]C, CSL20, CSL40, CSL60 and CSL80 diets contained corn steep liquor as replacement of urea at the rate of 0, 20, 40, 60 and 80% on the basis of nitrogen supply by corn steep liquor, respectively.
[2]CSL Corn Steep Liquor
[3]DCP Dicalcuim Phosphate

The CSL was obtained from the Rafhan Maize Products (Pvt.) Faisalabad, Pakistan, a multinational maize processing company. Animals were treated against all internal and external parasites and vaccinated against local diseases (Hemorrhagic Septicemia, Food and Mouth Disease) before the start of experiment. The experiment lasted for 90 days.

Feeding management and data collection

Calves were housed on a concrete floor in separate pens and no mechanical means were used to control the house temperature. Relative humidity and temperature during the experiment remained 66.27±6.11% and 38.21±4.21°C, respectively. Feed was offered twice (0600 and 1400 h) a day and calves were fed at ad libitum. During collection period, calves were fed 10% less feed in order to avoid refusal. Samples of feed offered and refused were collected for analysis. Feed offered and refused were weighed to calculate the dry matter intake (DMI). During collection periods, complete collections of urine and feces were made according to the procedure described by Williams et al. (1984). The feces of each animal were collected daily in specially designed drum, weighed; mixed thoroughly and 20% of it was sampled and dried at 55°C. At the end of each collection period, dried fecal samples were composited by animal and 10% of the composited samples of each animal were taken for analysis. Small special metal buckets fitted with a plastic pipe were made for urine collection. This plastic pipe ended in a large container. Before collection periods, the urine excreted by a calf was measured for three days to assess its volume in 24 hours. This was done to know the amount of 50% H_2SO_4 to be added to maintain urine pH at about 4.0 which minimizes the escape of urinary ammonia nitrogen (Shahzad et al., 2010).This measured amount of 50% H_2SO_4 was added into cylinders and whole day urine excreted by a calf was recorded. After weighing the urine voided by each animal in 24 hour, 20% of it was sampled and preserved at -20°C (Shahzad et al., 2010). At the end of each collection period, the frozen urine samples were thawed and composited by animal and 10% of the composited urine sample was used for N analysis.

Feed and fecal samples were analyzed for dry matter (DM) (AOAC, 1990) and crude protein (CP) (method of micro Kjeldhal, AOAC, 1990). Acid detergent fiber (ADF) was determined by using acetyletrimethyle ammonium bromide detergent in 0.5 M sulfuric acid (Goering and Van Soest, 1970) whereas nutrient detergent fiber (NDF) was determined by using sodium sulfite (Van Soest et al., 1991).

Carcass Characteristics

At the end of the trial, three animals from each group were slaughtered for evaluation of carcass characteristics. Calf body weight was recorded before slaughter. After slaughter, blood was collected. Weight of different components of offal was recorded. These included external organs (skin, head, and feet), thoracic organ (heart, lungs+trachea) and viscera (digestive tract, liver and kidney). All organs of digestive tract (reticulo-rumen+omasum (rumen), abomasum, and intestine) were weighed with or without digestive contents. Warm carcass weight (WCW) was also recorded. Dressing percentage was calculated following the procedure described by Atti et al. (2004). Carcass was split longitudinally into two halves. The left half-carcass was cut into primal cuts according to the method described by Diaz et al. (2002). Samples of meat were dried at 50ºC, ground (1-mm screen), and stored for subsequent analysis. Dry matter was determined by drying meat at 80°C until constant weight. Mineral contents were determined by ashing meat at 600°C for 8 hours. Nitrogen in meat was determined by Kjeldahal method as described by AOAC (1990). The Na and K contents of meat were determined by using flame photometer whereas Ca was determined from the dry ashed (550ºC) meat sample using atomic absorption spectrophotometer.

Statistical Analysis

The experiment was arranged in a randomized complete block design in 10 replications. Data were analyzed using ANOVA Test. In cases of significance, means were separated by Duncan's Multiple Range Test (Steel et al., 1997) by using the SPSS (version 17).

Results

Nutrient ingestion and digestibility

The dry matter intake was the highest (3.32 kg/day) by calves fed CSL40 diet and was the lowest (3.16 kg//day) by those fed CSL80 (Table 2). The CP intake was the highest ($P < 0.05$) in calves fed control and CSL40 diets followed by those fed CSL20, CSL60 and CSL80 diets. The NDF intake was highest ($P < 0.05$) in calves fed CSL60 (1082.43 g/day) diet followed by those fed CSL80, CSL20, CSL40 and C diets.

Table 2. Effect of varying levels of corn steep liquor when replaced with urea on nutrient intake and their digestibility in calves

Parameters	Diets[1]					
	C	CSL20	CSL40	CSL60	CSL80	SE
Nutrient intake						
Dry Matter (kg/day)	3.24[bc]	3.21[c]	3.32[a]	3.29[ab]	3.16[c]	11.83
Crude Protein (g/day)	638.48[a]	610.66[b]	628.43[a]	609.76[b]	582.36[c]	3.20
Neutral Detergent Fiber (g/day)	745.43[e]	851.17[c]	778.05[d]	1143.71[a]	1082.43[b]	23.27
Acid Detergent Fiber (g/day)	437.54[e]	469.25[d]	488.78[c]	774.56[a]	746.94[b]	20.89
Nutrient digestibility (%)						
Dry Matter	62.6	65.6	66.3	67.7	69.7	1.8
Crude Protein	76.6	76.5	77.2	77.3	78.0	2.2
Neutral Detergent Fiber	55[b]	59[a]	60.2[a]	60.2[a]	61.1[a]	1.7
Acid Detergent Fiber	47[b]	56[a]	55[a]	56[a]	57[a]	1.4

[1]C, CSL20, CSL40, CSL60 and CSL80 diets contained corn steep liquor as replacement of urea at the rate of 0, 20, 40, 60 and 80% on the basis of nitrogen supply by corn steep liquor, respectively.
[a-e]Significant differences (*P*<0.05) among treatments are indicated by different letters

The DM and CP digestibility remained unchanged ($P > 0.05$) in calves fed diets with varying levels of CSL (Table 2). However, NDF and ADF digestibilities by calves fed diets containing CSL were ($P < 0.05$) higher than those fed C diet (Table 2).

Carcass Characteristics

Pre-slaughter weight, warm carcass, dressing percentage, skin, heart, liver, kidney and heart weights remained unchanged across all diets (Table 3).

Mineral profile of Meat

Total meat ash and its Na, K, and Ca contents remained unchanged (Table 4).

Table 3. Effect of varying levels of corn steep liquor when replaced with urea on carcass characteristics in calves

Parameters	Diets[1]					
	C	CSL20	CSL40	CSL60	CSL80	SE
Pre-Slaughter weight (kg)	132.5[c]	133.4[c]	141.5[a]	137.6[b]	130.0[d]	1.11
Warm Carcass weight (kg)	60.8[b]	61.3[b]	65.8[a]	64.5[a]	61.3[b]	0.51
Dressing Percentage	45.9	46	46.1	46.3	46.2	0.24
Skin weight (kg)	14.9	15	14.9	14.9	14.9	0.06
Feet weight (kg)	4.5	4.45	4.45	4.45	4.5	0.05
Heart weight (kg)	0.75	0.76	0.75	0.75	0.74	0.01
Liver weight (kg)	2.0	2.1	2.0	2.0	2.1	0.02
Kidney weight (kg)	0.5	0.49	0.49	0.5	0.49	0.03
Lung weight (kg)	2.25	2.2	2.2	2.3	2.2	0.03

[1]C, CSL20, CSL40, CSL60 and CSL80 diets contained corn steep liquor as replacement of urea at the rate of 0, 20, 40, 60 and 80% on the basis of nitrogen supply by corn steep liquor, respectively.
[a-d]Significant differences (*P*<0.05) among treatments are indicated by different letters

Table 4. Effect of varying levels of corn steep liquor when replaced with urea on mineral profile of meat in calves

Minerals %	Diets[1]					
	C	CSL20	CSL40	CSL60	CSL80	SE
Ash	1	1.1	1.1	1.1	1.15	0.029
Na	0.4	0.4	0.4	0.41	0.41	0.029
K	0.85	0.9	0.95	0.93	1.01	0.026
Ca	0.23	0.24	0.28	0.29	0.3	0.023
Mg	0.34	0.35	0.35	0.35	0.35	0.03

[1]C, CSL20, CSL40, CSL60 and CSL80 diets contained corn steep liquor as replacement of urea at the rate of 0, 20, 40, 60 and 80% on the basis of nitrogen supply by corn steep liquor, respectively.

Discussion

Nutrient ingestion and digestibility

Feed consumption and nutrient intake increased by calves fed diets containing CSL and this increased feed consumption can be attributed to improved ruminal fermentation. This improved ruminal fermentation in animals fed diets containing CSL could be because CSL supplied minerals, peptides and amino acids when compared to those fed diet containing urea. The sugar and starch degrading bacteria require amino acids or peptides and cellulolytic bacteria use ammonia for their multiplication (Russell et al., 1990). The CSL being good source of amino acid and peptides might have triggered ruminal fermentation rapidly compared to diets without CSL. The CSL contains some fermentable carbohydrates which yield keto acids on hydrolysis. The ruminal ammonia nitrogen coupled with keto acids might have improved nitrogen (N) and carbon synchrony in the rumen, enhancing microbial proliferation leading to improved feed degradation (Sarwar et al., 1991). The CSL might have an adequate nutrient supply which not only enhanced microbial synthesis in the rumen but also has improved feed intake because increased microbial efficiency has been linked to increased feed intake (Haddad and Goussous, 2005). Some researchers have shown that bacterial growth and fermentation in the rumen are optimized when starch and protein are synchronized in the rumen (Nocek and Russell, 1988; Hoover and Stokes, 1991).

Nutrient ingestion like overall dry matter and fiber degradation in rumen play a pivotal role in controlling the feed intake (Baile and Forbes, 1974). Rate of microbial degradation in rumen helps in emptying the rumen which also helps in controlling the rate of passage of ingested feed (Mertens, 1977). The NDF, being an most important constituent of feed and forage, ferments and passes slowly through the reticulorumen and has a larger filling effect than other nutrients of diets (Van Soest, 1965, Martens, 1987). Many other partially filling effects including, chewing rate, indigestible NDF fraction, particle size and contractions of reticulum also limit the intake (Jarrige et al., 1986; Allen, 1997). Ruminant have an optimum capacity for maximum usage of different nutrients to fulfill their productive performance. In other words, the ability of healthy animals to metabolize feed varies with animal class and condition (Illus and Jessop, 1996).

There had been a significant difference in digestibility of NDF and ADF by calves fed diets containing CSL whereas digestibility of DM and CP remained unchanged across all diets. The replacement of urea with CSL was assumed to ferment at a rate which might have ensured sufficient gradually availability of nitrogen unit (i.e rumen ammonia), a vital requisite for microbial multiplication. This might have enhanced rumen microbial enzyme production leading to increased nutrient intake and digestibility (Sarwar and Nisa, 1999; Sarwar et al., 2004). This implies that the structural carbohydrates (cellulose and hemicellulose) will be more extensively fermented as evident by increased ADF and NDF digestibility in the present study.

Improved ADF and NDF digestibilities in animals fed CSL diets might be attributed to improved cellulytic and proteolysis activities in rumen. Improved fiber digestion was due to improve cellulose digestion by inhibiting the growth of lactate producing bacteria (Russell and Stroble, 1989). In present study

CSL supplementation improved the NDF and ADF digestion but CP digestibility was unaltered in calves. Analogous findings were observed by Dinius et al., (1976) who reported the non-significant CP digestibility by urea supplementation. Contrary to these findings, Muntifering et al. (1980) reported that retained N was higher with supplementation of urea. Likewise, Ding et al. (2008) reported that hemicelluloses had significantly higher digestibility in urea supplemented diets but found unaltered digestibilities of CP, NDF, and ADF. In contrary to findings of present study, Ding et al. (2008) reported an unaltered NDF digestibility.

The addition of CSL might have enhanced rumen microbial count (Nisa et al., 2008) and per unit enzyme production due to availability of N in diverse forms (ammonia N, peptides and amino acids) and keto acids (carbon skeleton) leading to increased nutrient digestibility (Sarwar and Nisa, 1999; Sarwar et al., 2004). Availability of ammonia N, peptides and amino acids along with fermentable energy source in CSL60 and CSL80 diets might have enhanced rumen microbial multiplication and more enzyme synthesis leading to improved CP degradability at ruminal level and microbial protein proportion at post ruminal level.

Growth performance

Increased weight gain in calves fed CSL containing diets was due to increased DMI. Atti et al. (2004) also reported that growing ruminants fed concentrate increased weight gain by stimulating rumen microbial activity, organic matter fermentation and microbial protein synthesis. The CSL contains macro and micro nutrients which might have influenced rumen ecology leading to increased volatile fatty acid (VFA) production. This might have increased ruminal microbial amino acid flow to intestine (Shahzad et al., 2010) and increased daily weight gain may be attributed to improved ruminal fermentation (Sarwar et al., 2004). This improved ruminal fermentation might have yielded increased VFA production because of enhanced microbial bio-mass resulting in increased digestion (Sarwar et al., 2004). This might have increased post-ruminal flow of amino acids (Weisberg et al., 1992). Shahzad et al. (2010) also reported improved weight gain of ruminants because of their better ruminal fermentation and increased microbial multiplication and microbial flow to the post ruminal supply of microbial protein and amino acids. Spicer et al. (1986) reported that 50% metabolizable protein from microbial crude protein (MCP) was required for cost-effective growing beef animals; however, reduced weight gain in calves fed C diet might be attributed to an inadequate supply of keto acids or imbalance between keto acids and rumen ammonia or both.

Carcass Characteristics

Carcass characteristics include the hot carcass weight, cold carcass weight, dressing percentage and bone to meat ratio. Dressing percentage is the weight of the carcass expressed as a percentage of live weight (Pethick et al., 2000). Different protein sources affect the carcass characteristics and meat composition. Of the VFAs produced from ruminal fermentation of carbohydrates, propionate is the major carbon substrate for gluconeogenesis (Russell and Gahr, 2000). The ruminal propionate concentration increases with the fermentation of starch (Ciccioli et al., 2003), thereby increasing the amount of carbon substrate available for gluconeogenesis.

There had been a non-significant difference in the carcass characteristics by calves across all diets. Non significant effects of carcass quality by calves fed CSL diets reflect the suitability and potential of CSL as a suitable ingredient to replace urea. Furthermore, encouraging effects of CSL also elucidates the absence of any undesirable constituent in it (Shahzad et al., 2010). However, Pethick et al. (2000) attributed the trend for decreased intra muscular fat to increased DMI. Growth of muscle tissues and extent and site of marbling in carcass affects the value and mass of meat in ruminant animals (Mahgoub et al., 1978; Hogg et al., 1992).

Mineral profile of Meat

Unaltered mineral profile (Na, K and Ca) of the meat by calves fed CSL diets is due to similar dietary mineral composition and their transformation in meat tissue. The results of the present study are supported by the findings of Comerford et al. (1992), who reported that meat composition was not affected by different feeding regimens in ruminants. Similarly, in another study, ash content of the carcasses remained unaltered as noticed by Szabo et al. (2001).

Conclusion

From the results of the present study, it can be concluded that animals fed CSL40 diet gained more weight and were cost-effective when compared to those fed control, 20%, 60% and 80% diets. Therefore, it can be concluded that CSL can be incorporated in the diets of male buffalo calves without any adverse effects on meat quality and mineral profile.

Acknowledgement

The authors are very thankful to the Higher Education Commission, Pakistan for their financial assistance to this study.

References

Allen, M. S. 1997. Relationship between fermentation acid production in the rumen and the requirement for physical effective fiber. *J. Dairy Sci.* 80: 1447-1462.

Andrew, P., and N. Tom. 2013. Corn Steep water/Liquor as a Feed Ingredient for Swine. *Shur-Gain, Nutreco Canada Inc.*

AOAC. 1990. Official methods of analysis (16th ed.). *Association of Official Analysis Chemists International. Arlington, Virginia, USA.*

Atti, N., H. Rouissi, and M. Mahouachi. 2004. The effect of dietary protein level on growth, carcass and meat composition of male goat kids in Tunisia. *Small Rumin. Res.* 54:89-97.

Baile, C.A., and J.M. Forbes. 1974. Control of feed intake and regulation of energy balance in ruminants. *Physiol. Rev*. 54: 160–169.

Ciccioli, N. H., R. P. Wettemann, L. J. Spicer, C. A. Lents, F. J. White, and D. H. Keisler. 2003. Influence of body condition at calving and postpartum nutrition on endocrine function and reproductive performance of primi-parous beef cows. *J. Anim. Sci.* 81:3107–3120.

Comerford, J. W., R. B. House, H. W. Harpster, W. R. Henning, and J. B. Cooper. 1992. Effects of forage and protein source on feedlot performance and carcass traits of Holstein and crossbred beef steers. *J. Anim. Sci.* 70:1022-1031.

Diaz, M. T., S. Velasco, V. Caneque, S. Lauzurica, F. Ruiz de Huidobr, C. Perez, J. Gonzalez, and C. Manzanares. 2002. Use of concentrate or pasture for fattening lambs and its effect on carcass and meat quality. *Small Rumin. Res.*43: 257-268.

Ding, J., Z. M. Zhou, L. P. Ren, and Q. X. Meng. 2008. Effect of Monensin and live yeast supplementation on growth performance, nutrient digestibility, carcass characteristics and ruminal fermentation parameters in lambs fed steam flaked corn-based diets. *Asian-Australian J. Anim.Sci*. 21: 547–554.

Dinius, D.A., M.S. Simpeon, and P.B. Marsh. 1976. Effect of monensin fed with forage on digestion and the ruminai ecosystem of steers. *J. Anim. Sci.* 42229234.

Goering, H.G., and P.J. Van Soest. 1970. Forage Fiber analysis. *Agricultural Handbook 379*, UPSDA.

Hoover, W.H., and S.R. Stokes. 1991. Balancing carbohydrates and proteins for optimum rumen microbial yield. *J. Dairy Sci*. 74: 3630-3644.

Haddad, S., and S. Goussous. 2005. Effect of yeast culture supplemented on nutrient intake, digestibility and growth performance of Awassi lambs. *Anim. Feed Sci. Tech.* V-118(issue3-8); 343-348.

Hogg, B. W., G. J. Mercer, and B. J. Mortimer. 1992. Carcass and meat quality attributes of commercial goats in New Zealand. *Small Rumin. Res.* 8:243-256.

Hull, S. R., B. Y. Yang, D. Venzke, K. Kulhavy, and R. Montgomery. 1996. Composition of corn steep water during steeping. *J. Agric. Food Chem.* 44:1857–1863.

Illius A. W., and N. S. Jessop. 1996. Metabolic constrains on voluntary intake in ruminants. *J. Anim. Sci*. 74:3052-3062. *J. Agric. Res.* 38:403.

Jarrige, R., C. Danarquilly, J. P. Dulphy, A. Hoden, J. Robelin, C. Beranger, Y. Geay, M. Joumet, C. Malterre. D. Micol, and M. Petit. 1986. The INRA "Fill Unit" system for predicting the voluntary intake of foragebased diets for nrminnnts: A review. *J. Anim. Sci.* 63: 1737.

Khan, M. A., M. Sarwar, M. Nisa, and M. S. Khan. 2004. Feeding value of urea treated corncobs ensiled with or without enzose (corn dextrose) for lactating cross cows. Asian-Aust. *J. Anim. Sci.* 17: 1093-1097.

Khan, M. A., M. Sarwar, M. S. Khan, M. S. Rehman, Mahr-un-Nisa, W. S. Lee, and H. S. Kim. 2008. Use of additives to capture nitrogen in ammoniated wheat straw: Intake, ruminal parameters, digestibility and nitrogen utilization in buffaloes. *Livest. Sci.* , 114: 347-353.

Mahgoub, O., A. J. Khan, R. S. Al-Maqbaly, J. N. Al-Sabahi, K. Annamali, and K. Al-Sakry.1978. Fatty acid composition of muscle and fat issues on Omani Jebel Akhdar goats of different sexes and weights. *Meat Sci.* 61:381-387.

Marten, G. C., C. C. Sheaffer, and D. L. Wyse. 1987. Forage nutritive value and palatability of perennial weeds. *Agronomy Journal*, 79:980-986.

Mertens, D. R. 1977. Dietary fiber components: Relationship to the rate and extent of ruminal digestion. *Fed. Proc.,* 36: 87–97.

Muntifering, R. B., B. Theurer, R. S. Swingle, and W. H. Hale. 1980. Effect of monensin on nitrogen utilization and digestibility of concentrate diets by steers. *.J. Anim. Sci.* 50:930.

Nisa, M., M. Sarwar, and M. A. Khan. 2004. Influence of ad libitum feeding of urea treated wheat straw with or without corn steep liquor on intake, in situ digestion kinetics, nitrogen metabolism, and nutrient digestion in Nili-Ravi buffalo bulls. *Aust. J. Agric. Res.* 55:235-241.

Nisa, M., M. Sarwar, and M. A. Khan. 2004b. Nutritive value of urea treated wheat straw ensiled with or without corn steep liquor for lactating Nili-Ravi buffaloes. *Asian-Aust. J. Anim. Sci*. 17:825-829.

Nisa, M., M. A. Shahzad, M. Sarwar, and N. A. Tauqir. 2008. Influence of additives and fermentation periods on silage characteristics,chemical composition and in-situ digestion kinetics of Jambo silage and its fodder in Nili buffalo bulls. *Turk. J. Vet. Anim. Sci*. 32(2): 67-72.

Nocek, J., and J. B. Russell. 1988. Protein and carbohydrate as an integrated system. Relationship of ruminal availability to microbial contribution and milk production. *J. Dairy Sci.* 71: 2070.

Pethick, D. W., B. L. McIntyre, and G. E. Tudor. 2000. The role of dietary protein as a regulator of the expression of marbling in feedlot cattle. Final report of project FLOT 209, *Meat and Livestock* Australia, Nth. Sydney.

Russell, R.W., and S. A. Gahr. 2000. Glucose Availability and Associated Metabolism. Farm Animal Metabolism and Nutrition. Pp 121. J.P.F. DiMello, ed. CABI Publishing.

Russell, J. B., and H. J. Strobel. 1989. Effect of ionophores on ruminal fermentation. *Appl. Environ. Microbiol.* 55: 1-6.

Russel, J. B., H. J. Strobel, and S. A. Martin. 1990. Strategies of nutrient transport by ruminal bacteria. J. Dairy Sci. 73:2996.

Sarwar, M., and M. U. Nisa. 1999. Effect of nitrogen fertilization and stage of maturity of mottgrass (Pennisetum purpureum) on its chemical composition, dry matter intake, ruminal characteristics and digestibility in Buffalo bulls. *Asian-Aust. J. Anim. Sci.* 12 (7): 1035-1039.

Sarwar, M., J. L. Firkins, and M. L. Eastridge. 1991. Effect of replacing neutral detergent fibre of forage with soy hulls and corn glutten feed for dairy heifers. *J. Dairy Science.* 74: 1006-1017.

Sarwar, M., M. A. Khan, and M. Nisa. 2004b. Effect of organic acids or fermentable carbohydrates on digestibility and nitrogen utilization of urea treated wheat straw in buffalo bulls. *Austr. J. Agric. Res.* 55:229.

Sarwar, M., M. A. Khan, and M. Nisa. 2004. Effect of organic acids or fermentable carboh ydrates on digestibility and nitrogen utilisation of urea-treated wheat straw in buffalo bulls. *Aust. J. Agric. Res.* 55:223-228.

Sarwar, M., M. A. Khan, and Z. Iqba. 2002.Feed Resources for Livestock in Pakistan: Status Paper. *Intl. J. Agri. Biol.* 4 : 186-192.

Shahzad, M. A., M. Sarwar, Mahr-un-Nisa, and M. Sharif. 2010. Corn steep liquor, a potential substitute of urea for growing lambs. *Egyptian J. Sheep and Goat Sci.* 5: 177-190.

Sindhu, A. A., M. A. Khan, M. U. Nisa, and M. Sarwar. 2002. Agro-industrial byproducts as a potential source of livestock feed - Review. *Int J. Agr. Biol.* 4(2):307- 310.

Steel, R. G. D., J. H. Torrie, and D. Dickey.1997. Principles and Procedure of Statistics. *A Biometrical Approach 3rd Ed. McGraw Hill BookCo. Inc., New York. pp*. 352-358.

Spicer, L. A., C. B. Theurer and T. H. Noon. 1986. Ruminal and post-ruminal utilization of nitrogen and starch from sorghum grain-, corn- and barley-based diets by beef steers. *J. Anim. Sci.* 62: 52 1,530.

Szabó, C., A. J. M. Jansman, L. Babnszky, E. Kanis, and M. W. A. Verstegen. 2001. Effect of dietary source and lysine:DE ratio on growth performance, meat quality, and body composition of growing-finishing pigs. *J. Anim. Sci.* 79:2857-2865.

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Method for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *J. Dairy Sci.* 74:3583-3597.

Van Soest, P.J. 1965. Use of detergents in analysis of fibrous feeds. III. Study of effects of heating and drying on yield of fiber and lignin in forages. *J. Assoc. Off. Anal. Chem.* 1965;48:785–789.

Weisbjerg, M. R., T. Hvelplund, and S. Hellberg. 1996. Effective rumen degradability and intestinal digestibility of individual amino acids in different concentrates determined in situ. *Anim, Feed Sci. and Tech*. 62: 179-188.

Williams, P. E. V., G. M. Innes, and A. Brewer. 1984. Ammonia treatment of straw via the hydrolysis of urea. Effect of dry matter and urea concentrations on the rate of hydrolysis of urea. *Anim. Feed Sci. Tech.* 11:103.