Asian-Aust. J. Anim. Sci.
Vol. 24, No. 7 : 946 - 951
July 2011

www.ajas.info
doi: 10.5713/ajas.2011.10407

Influence of Replacing Corn Grain by Enzose (Corn Dextrose) on Nutrient Utilization, Thyroid Hormones, Plasma Metabolites, and Weight Gain in Growing Lambs

M. Aasif Shahzad, M. Nisa and M. Sarwar*
Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad, Pakistan

ABSTRACT: The study was conducted to evaluate enzose (corn dextrose), a corn milling byproduct, as substitute for corn grain as energy in growing lambs. Five iso-caloric and iso-nitrogenous diets were formulated. The control diet (E0) had no enzose whereas enzose replaced 20, 40, 60 and 80% corn grain in E20, E40, E60 and E80 diets on the basis of energy supply, respectively. Fifty growing lambs were divided into 5 groups, 10 animals in each, in a randomized complete block design. Nutrients (dry matter, crude protein, neutral detergent fiber and acid detergent fibre) intake and digestibilities increased with gradual replacement of corn grain by enzose. Lambs fed E80 diet also retained higher nitrogen (N) than those fed E0 diet. Plasma glucose, T_3 and T_4 increased while urea N decreased in lambs receiving higher enzose content. Maximum weight gain was recorded in lambs fed diets containing maximum concentration of E as a replacement for corn grains. A better feed conversion ratio was recorded in lambs fed E80 compared with those fed E0 diet. The study suggests that enzose can be used as an economical feed ingredient to replace corn grain upto 80%, without any adverse effects on growth performance of growing lambs. (**Key Words :** Enzose, Thyroid Hormone, Biological Response, Lambs)

INTRODUCTION

In south asian countries, more than 50% nutritional requirements of ruminants are mainly met through fodders, forages, crop residues and rangelands. However, area under fodder production is continuously being depleted by competion for land by industrialization, urbanization and cash crops (Sarwar et al., 2002a; Shahzad et al., 2009a, 2010a). This scenario posses a threat to the sustainable supply of fodder to animals in addition to that caused by a seasonal scarcity of fodder. Forages and crop residues have low nutritional value as a ruminant feed due to low fermentable carbohydrates and high lignifications (Klopfenstein et al., 1987). Rangelands constitute a large share of the regional areas that are undeveloped and are being exploited by nomadic grazing. However, these areas contribute about 60% of the nutritional needs of small ruminants (Zaffruddin, 1997). The combination of travel in search of food and poor nutritional value of range vegetation not only increases the nutritional requirements of ruminants but also aggravates the situation of underfeeding which prevents the animals from achieving their genetic potential. Sarwar et al. (2002b) also reported that ruminants were getting only 74% of the required total digestible nutrients, ranking energy as first limiting nutrient. About 50% improvement in ruminant productivity can be attained by ensuring sustainable supply of macro and micro nutrients which overshadows the problem of a poor or inferior gene pool (Shahzad et al., 2009b).

An ever increasing demand for quality meat underlines the significance of commercial indoor meat production enterprises for the optimum conversion of available nutrients required to produce valuable end products like meat. However, high cost and irregular supply of available energy ingredients not only limit animal productivity but also increases cost of production and decreases profit margin.

This situation invites the attention of ruminant nutritionists to explore new economical suitable feedstuffs for ruminants to alleviate or dilute the influence of costly energy feed ingredients. Agro-industrial byproducts are good source of energy and protein and may have great potential as a feed stuff for small ruminants. The biological evaluation of these by products may bridge the gap between

* Corresponding Author : M. Sarwar. Tel: +92-41-9201088, E-mail: drms01@gmail.com
Received November 9, 2010; Accepted February 21, 2011

nutrient availability and demand and could favour cost effective ruminant production (Shahzad et al., 2010b).

Enzose, derived from the enzymatic conversion of corn starch, is a byproduct of the corn milling industry, contains 85% dextrose, with a pH of 3.5-4.5. It is a rich source of fermentable carbohydrates and is usually inexpensive (Sarwar et al., 2007). It can be a promising substitute of concentrate (Khanum et al., 2007) for other expensive energy sources like corn grains. However, suggesting enzose as a potential replacement for a costly energy feed ingredient requires a biological evaluation in order to determine its suitability and extent of its possible inclusion in animal diets. However, scientific information about the use of enzose in animal diets as an energy source or replacement energy ingredient is scanty. Therefore, the present study was conducted to evaluate the nutritive value of enzose as an energy source to replace corn grains on performance of growing lambs.

MATERIALS AND METHODS

Diets and animals

Five iso-caloric and iso-nitrogenous diets were formulated according to the requirements as prescribed by NRC (1985). Enzose was obtained from the Rafhan Maize Products (Pvt.) Faisalabad, Pakistan, a multinational maize processing company. Enzose replaced corn grains at the rate of 0, 20, 40, 60 and 80% rations on the basis of energy supply by corn grains in E0, E20, E40, EL60 and E80 rations, respectively (Table 1). Experimental diets were formulated on weekly basis in order to avoid any hazard that may arise due to sweet, sticky and liquid nature of the enzose. Fifty growing male *Lohi* lambs with an average weight of 30±4.31 kg per animal were divided into 5 groups, 10 animals in each, in a randomized complete block design. Animals were dewormed against endo and ecto- parasites. The trial lasted for 90 days. First 20 days were adaptation period while every 10 alternate days of remaining 70 days served as collection period.

Feeding management and data collection

Lambs were housed on a concrete floor in separate pens without mechanical means 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 (0300 and 1400 h) a day and animals were fed at *ad libitum* but with a 10% weigh back during each collection period. Representative samples of feed offered were collected for analysis. Feed offered and orates were weighed to calculate the dry matter intake

Table 1. Ingredients and chemical composition of experimental diets

Ingredients (%)	Experimental diets[1]				
	E0	E20	E40	E60	E80
Corn grains	29.59	23.70	17.75	11.8	5.90
Wheat straw	12.00	12.00	12.00	12.00	12.00
Enzose	0.00	5.89	11.84	17.79	23.69
Canola meal	14.00	14.00	14.00	14.00	14.00
Sunflower meal	6.00	6.00	6.00	6.00	6.00
Cotton seed meal	8.10	8.10	8.10	8.10	8.10
Corn gluten 60%	0.00	0.70	1.50	2.30	3.05
Rice polishing	7.21	7.21	7.21	7.01	7.00
Maize bran	7.00	7.00	7.00	7.00	7.00
Maize oil cake	8.10	7.40	6.60	6.00	5.26
Maize oil	1.00	1.00	1.00	1.00	1.00
$NaHCO_3$	2.00	2.00	2.00	2.00	2.00
Urea	2.00	2.00	2.00	2.00	2.00
DCP	2.00	2.00	2.00	2.00	2.00
NaCl	1.00	1.00	1.00	1.00	1.00
Chemical composition (%)					
Dry matter	91.10	89.90	88.70	87.50	86.30
Crude protein	18.00	18.00	18.00	18.00	18.00
Total digestible nutrients	70.00	70.00	70.00	70.00	70.00
Neutral detergent fiber	30.60	29.80	29.10	28.30	27.60
Acid detergent fiber	19.76	19.55	19.21	18.92	18.50

[1] E0, E20, E40, E60 and E80 diets contained enzose as replacement of corn grains at the rate of 0, 20, 40, 60 and 80% on the basis of energy supply by corn grains, respectively

(DMI) by subtraction. During collection periods, complete collections of urine and faeces were made according to the procedure described by Williams et al. (1984). The faeces of each animal were collected daily in specially designed dung drums, weighed, mixed thoroughly and 20% of it was sampled and dried at 55°C. At the end of each collection period, dried faecal samples were composited by animal and 10% of the composited samples of each group 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, fresh urine was titrated against 50% H_2SO_4 to know the volume required to maintain urine pH at about 4.0 to minimize the escape of urinary ammonia nitrogen. Whole day urine produced by a lamb was recorded and 50% H_2SO_4 was added in urine collecting cylinder according to titration then 20% of it was sampled and preserved at -20°C (Shahzad et al., 2008a). At the end of each collection period, the preserved urine samples were composited by animal after thawing and 10% of the composited sample was used for analysis.

Analysis

Feed and faecal samples were analyzed for dry matter (DM; method 930.15; AOAC, 1990) and crude protein (CP; method (Kjeldhal) 955.04; 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). Neutral detergent fiber (NDF) was determined by using sodium sulfite and amylase (Van Soest et al., 1991). In each collection period, blood samples (10 ml) were drawn from the jugular vein in two heparinized vacuum tubes (VT-100H, Venojet, Terumo Co., Tokyo, Japan) at 3, 6, 9 and 12 h post- feeding and were stored in cool box packed with ice bags and transported to the laboratory for processing and analysis. Blood plasma was harvested as per procedure of Harold (1976).

Nutrients digestibilities were done using the total collection method as described by Nisa et al. (2004) while N balance was determined using equations as described by NRC (2001). Triiodothyroxin (T_3) and thyroxin (T_4) concentrations were analyzed by the methods of Todini et al. (2007). Serum glucose (Davies et al., 2007) and urea N (Bull et al., 1991) were also analyzed. Economics of using enzose as energy source was also calculated.

Statistical analysis

The data were analyzed using a Randomized Complete Block Design. In cases of significance, means were separated by Duncan's Multiple Range Test (Steel and Torrie, 1984). The contrasts were determined by using the SPSS (version 10.0.1).

RESULTS AND DISCUSSION

Nutrient ingestion and digestibilities

The DMI increased in lambs when corn grain was gradually replaced by enzose (Table 2). Similarly, intakes of CP, ADF and NDF followed the same trend. Nutrient digestibilities also increased when corn grains were

Table 2. Nutrients intake, digestibilities and growth performance in lambs fed diets with graded replacement of corn grains by enzose

Parameters	Diets[1]					
	E0	E20	E40	E60	E80	SE
Nutrients intake (g/d)						
Dry matter	1,422[c]	1,465[bc]	1,514[b]	1,544[ab]	1,561[a]	18.51
Crude protein	255.96[c]	263.7[bc]	272.52[b]	277.92[ab]	280.98[a]	3.34
Neutral detergent fiber	435.13[c]	436.57[bc]	440.57[b]	436.95[a]	430.84[ab]	4.47
Acid detergent fiber	280.99[c]	286.41[bc]	290.84[b]	292.12[a]	288.78[ab]	2.43
Nutrients digestibilities						
Dry matter	60.21[c]	63.42[bc]	63.71[b]	64.32[ab]	65.32[a]	0.96
Crude protein	70.11[c]	70.25[bc]	70.93[b]	71.36[ab]	72.52[a]	0.49
Neutral detergent fiber	56.55[c]	56.98[bc]	57.68[b]	58.12[ab]	58.84[a]	1.12
Acid detergent fiber	49.22[c]	50.35[bc]	51.67[b]	52.19[ab]	52.36[a]	0.89
Growth performance						
Daily wt. gain (g/d)	200[c]	206[c]	216[ab]	226[a]	220[b]	6.21
Cost (U$) of feed /kg live weight produced	1.66[a]	1.63[b]	1.59[b]	1.53[c]	1.54[c]	0.08
Feed conversion ratio	7.12	7.08	7.05	6.97	7.03	0.36

[a, b, c] Means in a row with different superscripts differ significantly ($p<0.05$).

[1] E0, E20, E40, E60 and E80 diets contained enzose as replacement of corn grains at the rate of 0, 20, 40, 60 and 80% on the basis of energy supply by corn grains, respectively.

Table 3. Nitrogen dynamics in lambs fed diets with graded replacement of corn grains by enzose

Nitrogen (g/d)	Diets[1]					
	E0	E20	E40	E60	E80	SE
Intake	40.95[c]	42.19[bc]	43.60[b]	44.47[ab]	44.96[a]	2.21
Faecal outgo	12.32	13.11	13.22	13.55	13.85	0.87
Apparent absorption	28.63[c]	29.08[bc]	30.38[b]	30.92[ab]	31.11[a]	1.92
Urinary outgo	0.28[c]	0.32[bc]	0.34[b]	0.38[ab]	0.41[a]	0.12
Balance	28.35[c]	28.76[bc]	30.04[b]	30.54[ab]	30.70[a]	0.21

[a, b, c] Means in a row with different superscripts differ significantly ($p<0.05$).

[1] E0, E20, E40, E60 and 80 diets contained enzose as replacement of corn grains at the rate of 0, 20, 40, 60 and 80% on the basis of energy supply by enzose, respectively.

replaced with enzose (Table 2). Nitrogen (N) balance also followed the similar trend (Table 3).

Higher intake of nutrients by lambs fed E60 and E80 diets might be attributed to enhanced digestibility of these nutrients which thereby improved voluntary feed intake (Hogan, 1996; Shahzad et al., 2008b). Sarwar et al. (1991) also reported that a faster digestion rate of the potentially digestible feed enhanced DMI. Increased digestibility of nutrients may be due to readily fermentable carbohydrates supplied by enzose. This might have resulted in increased ruminal fermentation and ruminal microbial activity which subsequently increased nutrient digestibility. Increased digestibility of DM, CP and NDF by supplementation of readily fermentable carbohydrates (molasses) has also been reported by Doyle and Panday (1990). Findings of this study are in concordance with Kozloski et al. (2006) who noticed that readily fermentable carbohydrates improved DM and organic matter (OM) digestibilities in lambs. Supplementation of readily fermentable carbohydrates stimulates fiber digestion, reducing the lag time (Cheng et al., 1977; Hiltner and Dehority, 1983; Wanapat et al., 1985; Galloway et al., 1991). O'Kiely (1991) and Moore and Kennedy (1994) also reported that fermentable carbohydrates (molasses) stimulated better microbial activity which resulted in improved OM digestibility (Nisa et al., 2004; Sarwar et al., 2004).

Growth performance

Lambs fed E40, E60 and E80 diets achieved a higher weight than those fed E0 and E20 diets (Table 2). Increased weight gain with gradual replacement of corn grain by enzose might be attributed to either higher ruminal volatile fatty acid production or post rumen supply of amino acids or both due to efficient microbial proliferation and feed utilization.

Cost of feed per kg live weight produced was higher in lambs fed E0 diet than all other treatments. Minimum cost of production was observed when corn was replaced with enzose at the rate of 60 and 80% (Table 2). However, feed conversion ratio remained unaltered among all treatments.

Results of this study supported the findings of Brooks and Iwanaga (1967) who reported enhanced weight gain by lambs fed diets containing a fermentable energy source (molasses). Houdijk (1998) noticed that incorporating fermentable carbohydrates in an animal's diet results in efficient utilization of excess indigestible protein which would otherwise be used to produce energy. It also results in beneficial alteration in composition of microbial population as indicated by lower ammonia and higher VFA concentrations (Konstantinov et al., 2004). Microorganisms may have retained a greater quantity of N in the gut for their own growth (Sauer et al., 1980) resulting in utilization of N in the cecum and colon (Kass et al., 1980; Rowan et al., 1992) which results in improved weight gain by the animal.

Thyroid hormones and plasma metabolites

The thyroid hormones increased with increasing the concentration of E as replacement of corn grains (Table 4).

Table 4. Hormonal profile, glucose and urea N in lambs fed diets with graded replacement of corn grains by enzose

Items	Diets[1]					
	E0	E20	E40	E60	E80	SE
T_3 (n mol/L)	0.69[d]	0.87[cd]	0.99[c]	1.15[b]	1.32[a]	0.15
T_4 (n mol/L)	25.32[d]	27.11[cd]	35.26[c]	41.25[b]	52.37[a]	4.14
Plasma metabolites (mg/100 ml)						
Glucose	64.21[d]	65.21[cd]	66.41[c]	67.43[b]	68.72[a]	0.87
Urea N	26.32[a]	24.09[b]	23.01[c]	21.06[cd]	19.52[d]	3.25

[a, b, c] Means in a row with different superscripts differ significantly ($p<0.05$).

[1] E0, E20, E40, E60 and E 80 diets contained enzose as replacement of corn grains at the rate of 0, 20, 40, 60 and 80% on the basis of energy supply by enzose, respectively.

Higher concentrations of T_3 and T_4 hormones are related with nutritional status and metabolic rates (Todini et al., 2007). Todini et al. (2007) observed higher concentrations of plasma T_4 concentration in sheep that ingested more energy due to higher dry matter intake.

Higher glucose concentration in lambs fed E80 diet might be attributed to efficient fermentative activities by rumen microbes which might have ensured availability of digestive gluconeogenesis precursors (Knapp et al., 1991). In ruminants the principal precursors are propionate and amino acids, with lactate and glycerol making minor contributions to glucose production. Higher dry matter intake containing fermentable nutrients has also been reported to enhance propionate production in ruminants (Nisa et al., 2004). Increased glucose concentration in ruminants with high energy status due to high dry matter intake has also been reported.

Increased urea N in lambs fed E0 diet might be attributed to the rapid hydrolysis of urea in their rumen which resulted in its enhanced absorption in the blood. However, decreased plasma urea N in lambs fed E80 might be attributed to hydrolysis of E in rumen and its efficient utilization by microbial bodies. It might be attributed to synchronized availability of carbon and nitrogen units at ruminal level as E does contain carbohydrates compared to urea which on hydrolysis yields only ammonia. Decreased plasma urea N in lambs fed E80 diet might be attributed to matching ruminal hydrolysis of E and urea which might have synchronized the availability of carbon and N units at ruminal level leading to synchrony of carbon and N units at ruminal level. In addition low pH of E might have reduced the rapid ammonia escape, compared to hydrolysis of dietary urea N, through rumen wall by maintaining it in less absorptive phase (i.e. ionic form, NH^+_4).

Increased nutrient ingestion, utilization and weight gain reflect the suitability and potential of enzose as an economical energy ingredient when used to replace corn grains upto 80% of the diet of growing lambs.

REFERENCES

AOAC. 1990. Official methods of analysis, 15 Edition, Vol. 1. Association of Official Analytical Chemists, Virginia, USA.

Brooks, C. C. and I. I. Iwanaga. 1967. Use of cane molasses in swine diets. J. Anim. Sci. 26:741-745.

Bull, R. C., D. O. Everson, D. P. Olson, K. W. Kelly, S. Curtis and G. Tzou. 1991. Concentration of serum constituents in cold-stressed calves from heifers and inadequate protein and (or) energy. J. Anim. Sci. 69:853-863.

Cheng, K. J., D. E. Akin and J. W. Costerton. 1977. Rumen bacteria: interaction with particulate dietary components and response to dietary variation. Fed. Proc. 36:193-197.

Doyle, P. T. and S. B. Panday. 1990. The feeding value of cereal straws for sheep. III. Supplementation with minerals or minerals and urea. Anim. Feed Sci. Technol. 29:29-43.

Galloway, D. L., A. L. Goetsch, L. A. Forster, W. Sun and Z. S. Johnson. 1991. Feed intake and digestion by Holstein steers fed warm or cool season grass hays with corn, dried molasses, or wheat middlings. J. Dairy Sci. 74:1038-1046.

Goering, H. G. and J. P. Van-Soest. 1970. Forage fiber analysis. Agricultural Handbook, vol. 379. UPSDA.

Harold, V. 1976. Practical clinical biochemistry. 4th Ed. Arnold-Heinemann Publisher (Pvt.) New Delhi. India.

Hiltner, P. and B. A. Dehority. 1983. Effect of soluble carbohydrates on digestion of cellulose by pure cultures of rumen bacteria. Appl. Environ. Microbiol. 46:642-648.

Hogan, J. 1996. Feed intake. In: Ruminant Nutrition and Production in the Tropics and Subtropics (Ed. B. Bakrie, J. Hogan, J. B. Liang, A. M. M. Tareque and R. C. Upadhyay). ACIAR, Canberra, pp. 47-58 .

Houdijk, J. G. M. 1998. Effects of non-digestible oligosaccharides in young pig diets. Ph.D. Diss., Wageningen Univ., Wageningen, the Netherlands.

Kass, M. L., P. J. Van-Soest, W. G. Pond, B. Lewis and R. E. McDowell. 1980. Utilization of dietary fiber from alfalfa by growing swine. 1. Apparent digestibility of diet components in specific segments of the gastrointestinal tract. J. Anim. Sci. 50:175-191.

Khanum, S., M. Nisa, M. Mushtaq, M. Sarwar and M. Hassan. 2007. Influence of replacement of concentrate with enzose (corn dextrose) and corn steep liquor on nutrient intake in Nili Ravi buffalo bulls. Italian J. Anim. Sci. 6:567-570.

Klopfenstein, T. J., L. Roth, S. Fernandez-Rivera and M. Lewis. 1987. Corn residues in beef production systems. J. Anim. Sci. 65:1139-1148.

Knapp, D. M., R. R. Grummer and M. R. Dentine. 1991. The response of lactating dairy cows to increasing levels of whole roasted soybeans. J. Dairy Sci. 74:2563-2572.

Konstantinov, S. R., A. Awati, H. Smidt, B. A. Williams, A. D. L. Akkermans and W. M. De-Vos. 2004. Specific response of a novel and abundant Lactobacillus amylovorus-like phylotype to dietary prebiotics in the ileum and colon of weaning piglets. Appl. Environ. Microbiol. 70:3821-3830.

Kozloski, G. V., L. M. Bonnecarrere, R. L. Sanchez, M. V. Cadorin, D. Reffatti and L. D. Perez. 2006. Intake and digestion by lambs of dwarf elephant grass (*Pennisetum purpureum* Schum. cv. Mott) hay or hay supplemented with urea and different levels of cracked corn grain. Anim. Feed Sci. Technol. 125: 111-122.

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.

NRC. 1985. Nutrient Requirements of Sheep, 6th ed. National Research Council, National Academy of Sciences, Washington, DC.

NRC. 2001. Nutrient requirements of dairy cattle. 6th rev. ed. Natl. Acad. Sci., Washington, DC.

O'Kiely, P. A. 1991. Note on the influence of five absorbants on silage composition and effluent retention in small-scala silos. Irish J. Agric. Res. 30:153-158.

Rowan, A. M., P. J. Moughan and M. N. Wilson. 1992. The flows of deoxyribonucleic acid and diaminopimelic acid and the digestibility of dietary fiber components at the terminal ileum, as indicators of microbial activity in the uppor digestive tract of ileostomized pigs. Anim. Feed Sci. Technol. 36:29-141.

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

Sarwar, M., M. A. Khan, M. Nisa and Z. Iqbal. 2002a. Dairy industry in Pakistan: A Scenario. Int. J. Agric. Biol. 3:420-436.

Sarwar, M., M. A. Khan and Z. Iqbal. 2002b. Feed resources for livestock in Pakistan. Status Paper. Int. J. Agric. Biol. 4:186-192.

Sarwar, M., M. A. Shahzad, M. Nisa and A. Sufyan. 2007. Influence of bovine somatotrophin and replacement of corn dextrose with concentrate on the performance of mid-lactating buffaloes fed urea-treated wheat straw. Turk. J. Vet. Anim. Sci. 31:259-265.

Sauer, W. C., A. Just, H. H. Jorgensen, M. Fekadu and B. O. Eggum. 1980. The influence of diet composition on the apparent digestibility of crude protein and amino acids at the terminal ileum and over all in pigs. Acta Agric. Scand. 30: 449-468.

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

Shahzad, M. A., M. Nisa and M. Sarwar. 2010b. Nutrients utilization, nitrogen dynamics and weight gain in growing buffalo calves fed graded replacement of urea by corn steep liquor. 5th International seminar on tropical Animal Health and Production. 19-22 October Yogyakarta, Indonesia.

Shahzad, M. A., M. Sarwar, M. Nisa, A. Iqbal and M. Riaz. 2009a. Feed consumption and weight gain of growing buffalo calves as influenced by feeding fermentable energy source in corncobs based diet. Pak. J. Zool. 9:707-710.

Shahzad, M. A., M. Sarwar, A. Aqile, M. Nisa, K. Mahmood and M. S. Khan. 2009b. Impact of stage of maize fodder harvest on chemical composition, nutrient digestibilities and nitrogen balance in buffalo bulls. Pak. J. Zool. 9:717-720.

Shahzad, M. A, M. Sarwar and M. Nisa. 2008a. Influence of altering dietary cation anion difference on milk yield and its composition of early lactating *Nili Ravi* buffaloes in summer. Livest. Sci. 113:133-143.

Shahzad, M. A., M. Sarwar and M. Nisa. 2008b. Influence of varying dietary cation anion difference on serum minerals, mineral balance and hypocalcemia in *Nili Ravi* buffaloes. Livest. Sci. 113:52-61.

Steel, R. G. D. and J. H. Torrie. 1984. Principles and procedures of biostatistics. 2nd ed. McGraw-Hill Book Co., Inc., New York, NY.

Todini, L., A. Malfatti, A. Valbonesi, M. Trabalza-Marinucci and A. Debenedetti. 2007. Plasma total T_3 and T_4 concentration in goats at different physiological stages, as affected by the energy intake. Small Rumin. Res. 68:285-290.

Van-Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccarides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.

Wanapat, M., F. Sundstol and T. H. Garmo.1985. A comparison of alkali treatment methods to improve the nutritive value of straw. I. Digestibility and metabolizability. Anim. Feed Sci. Technol. 12:295-302.

Williams, P. E., G. M. Imes and A. Brewer. 1984. Ammonia treatment of straws via hydrolysis of urea: 1. Additions of soybean (urease), sodium hydroxide and molasses; effects on the digestibility of the urea-treated straw. Anim. Feed Sci. Technol. 11:115-121.

Zaffaruddin, C. 1977. Development of rangeland in desert areas of Pakistan. Proc. Intl. Conf. Alternative strategies for desert development. UNNITAR. Pergamon press, New Yark, USA.