Pakistan Vet. J., 2007, 27(1): 35-41.

CURRENT FEEDING MANAGEMENT OF PERI-URBAN DAIRY BUFFALOES AND SCOPE FOR IMPROVEMENT

G. HABIB, A. HAMEED AND M. AKMAL[1]

Animal Nutrition Department; [1]Agronomy Department, NWFP Agricultural University, Peshawar, Pakistan

ABSTRACT

A study was conducted to assess the current feeding status of peri-urban dairy buffaloes around Peshawar city. A total of 32 buffalo farms at 8 different locations were randomly selected. Data on feed availability and feeding practices were collected during berseem and maize fodder seasons. Blood urea concentrations in the buffaloes were measured and related to the feeding management. Six different concentrate mixtures commonly prepared on the farms were identified. These were analysed and found imbalanced in energy/protein and mineral supply. This together with feeding of the concentrate at a flat rate without considering milk yield resulted in overfeeding of protein to low producers and at the same time caused inadequate nutrition of high producing buffaloes. Buffaloes producing 4 to 6 liters of milk/day received 200 to 1400 g crude protein above requirements, while those yielding 10-12 liters of milk suffered from deficiency of both protein and energy. Plasma urea levels varied due to farms ($P<0.05$) and fodder seasons ($P<0.05$) and varied from 36.15 to 39.09 mg/100 ml during berseem and from 21.74 to 28.01 mg/100 ml during maize fodder season. Elevated plasma urea levels were suggestive of causing fertility problems in the buffaloes and wastage of dietary protein. It was concluded that nutritional manipulation to mitigate nutrient losses and improve the efficiency of utilization of diet in peri-urban buffaloes would require technical interventions of the existing conventional feeding systems.

Key words: Buffalo, feeding management, blood urea, protein-energy balance.

INTRODUCTION

Dairying is one of the most important part of livestock sector. In Pakistan, milk alone is valued as 62% of the total livestock and poultry products. The economic value of milk is higher than major grain crops in the country and valued as Pak. Rupees 276.047 million Vs. 202,064 million for grain crops and 238.870 million for cotton plus wheat crops (Agri. Statistics of Pakistan, 2003). Pakistan possesses 25.5 million heads of dairy cattle and 28.4 million buffaloes that produce 32 million tons milk annually (Economic Survey of Pakistan, 2005-06). The number of dairy animals increased from 11 million in 1992-93 to 16 million in 1999-2000. The per head milk production of local dairy animals under existing farm conditions is relatively low. Among dairy buffaloes, 98% are producing less than 10 liters of milk/day. Most of the increase in milk yield has resulted from increase in the number of cattle and buffaloes, while yield increase per animal has contributed relatively little to milk production growth.

In Pakistan, about 65% of the milk is contributed by buffaloes. Traditionally, buffalo milk in the country is preferred over cow milk and this has led to rapid increase over 2.8% per annum in the buffalo population. In Pakistan, buffaloes are kept under two major dairy production systems viz. rural smallholding system and urban/peri-urban system. Urban and peri-urban farms are mostly landless and are located within or close to major towns and cities. The higher demand of milk in urban population has been a driving force for establishment of urban and peri-urban farms. The number of such commercial buffalo farms has increased three folds during 1986 to 1996. During the same period, urbanization in Pakistan has also increased by 78%. In view of the projected increase in urban human population from the current level of 40 million to 140 million in the year 2030 (FAO, 2003), the number of peri-urban buffalo farms in future would also rapidly increase to cater the need for milk and meat.

In urban and peri-urban commercial dairy farms, feed accounts for more than two third of the operational cost. This is because animals are stall-fed all the times with purchased feed and fodder. Moreover, the system is highly intensive and profit motivated, the animals are fed large amount of concentrates to get more milk. However, feeding management is mostly traditional which adds to feed cost. Garcia *et al*. (2003) calculated various farm input cost per 100 kg fat corrected milk (FCM) in rural and commercial peri-urban farms in Pakistan. In peri-urban farms, feed cost exceeded other input cost (land, capital and labour) and was estimated as Pak. Rupees 87 per 100 kg FCM, while it varied from Pak. Rupees 16 to 26 per 100 kg FCM in rural smallholders. A sound intervention strategy to increase farm income should focus on two fronts; firstly, lowering feed cost, and secondly, increasing buffalo productivity. Both require improved nutritional management to increase the efficiency of feed utilization in buffaloes. The present study was performed to evaluate the existing feeding management of urban and peri-urban buffaloes and to suggest relevant interventions for its improvement.

MATERIALS AND METHODS

A total of 32 buffalo farms over 8 different locations namely Sufaid Dheri, Nothia, Sarband, Achini, Nodeh bala, Pawaki, Shiekh Mohammad and Swati Gate, located within a radius of 10 km around Peshawar city, Pakistan were used in the present study. Four farms in each location were randomly selected. Data regarding feed availability, ration formulation and preparation, feeding practices and other relevant farm practices were collected using a questionnaire. Feed samples from all farms were collected, pooled for each location and analysed for dry matter (DM), ash, crude protein (CP), ether extract (EE) and crude fiber according to AOAC (1990). Total digestible nutrients (TDN) values were calculated as suggested by NRC (2001). The contents of calcium and phosphorus in concentrate ingredients were those determined earlier in this laboratory (unpublished). NRC (2001) nutrient recommendations of dairy cows were used to estimate protein and TDN requirements of buffaloes. Nutrient requirement for a range of milk production was matched with the supply calculated from typical rations practiced by majority of the farmers.

Blood samples from jugular vein were collected from five buffaloes in three randomly selected farms at three locations during berseem and maize fodder seasons. Plasma was separated by centrifugation at 3000 rpm for 10 minutes and processed for urea analysis, as described by Richter and Laponte (1962). The data were recorded in Excel worksheets and statistics where applicable was performed using GLM procedure of SAS (2001).

RESULTS AND DISCUSSION

Composition of concentrate mixtures

Nutrient composition of the concentrate ingredients used in conventional feeding of urban and peri-urban buffaloes is given in Table 1. All ingredients were high in protein (13.00-24.97 g/100g DM) and phosphorus (0.8-1.04 g/100g DM) but were low in calcium (0.13-0.23 g/100g DM). Cottonseed cakes due to undecorticated nature had maximum fiber contents. Ether extract (crude fat) contents were higher in oil cakes and represented residual lipids after mechanical extraction. Six most common concentrate mixtures prepared from these ingredients and fed as supplement to buffaloes were identified. Composition of these mixtures is shown in Table 2. These were classified as conventional mixtures which the farmers had adopted on their own or learned from their elders. Among these, concentrate mixture-4, composed of equal proportions of cottonseed cake (CSC), wheat bran (WB) and dried bread (DB) was used by majority of (40%) farmers, followed by mixture-1, containing equal parts of CSC and WB used by 26% farmers. The other mixtures contained variable quantity of the above ingredients together with maize oil cake (MOC). Among these, mixture-4 was used by majority of farmers and was found least expensive (Rs. 9.97/kg). Ingredient composition of the mixtures was not constant and varied both within the farm and among the farms and depended on the relative market price, availability and financial capacity of the farmer. The quality of concentrate supplements was never synchronized with the type of fodder available that contributed to imbalanced nutrition and low cost effectiveness of the supplements. Farmers had little or no knowledge of feed quality especially their protein, energy and mineral contents.

Energy and protein values of the concentrate mixtures

Nutrient composition of the concentrate mixture shown in Table 2 clearly shows that these were imbalanced in energy/protein and Ca/P ratios. The concentrate mixtures, with the exception of 4 and 5 that

Table 1: Nutrient composition of feed ingredients used in conventional dairy concentrate mixtures

Feed	Dry matter (%)	Ash	Crude protein	Crude fiber	Ether extract	Ca	P	TDN*
		as g/100 g dry matter						
Cottonseed cake (undec)	91.84 ± 0.04	10.83 ± 4.08	24.97 ± 0.92	28.19 ± 0.78	7.31 ± 1.51	0.19	1.04	83.93
Maize oil cake	93.83 ± 2.25	1.76 ± 0.28	20.50 ± 3.83	11.07 ± 1.81	7.81 ± 0.40	0.23	1.00	90.59
Wheat bran	91.12 ± 1.06	3.86 ± 1.62	17.01 ± 0.99	11.06 ± 1.59	3.74 ± 0.38	0.13	1.40	84.10
Dried bread	92.34 ± 1.23	2.67 ± 0.56	13.00 ± 2.10	8.48 ± 2.53	1.45 ± 1.16	0.19	0.80	83.03

*TDN values were calculated as suggested by NRC (2001.)

Table 2: Six common conventional home-made concentrate mixtures used by farmers in urban and peri-urban buffalo farms

Ingredients	**1**	**2**	**3**	**4**	**5**	**6**
Cottonseed cake	50	33	67	33	50	50
Wheat bran	50	67	33	33	25	25
Maize oil cake	0	0	0	0	0	25
Dried bread	0	0	0	33	25	0
Total	100	100	100	100	100	100
Nutrient composition						
Crude protein (%)	20.96	19.60	22.32	18.15	19.86	19.87
TDN (%)	75	75	73	75	75	78
Calcium (g/kg)	01.06	01.05	1.5	01.08	01.08	01.08
Phosphorus (g/kg)	12.02	12.08	11.06	10.07	10.07	11.02
Cost in Rupees/kg	11.10	09.98	12.22	09.97	11.15	12.90
Farmer use (%)	26	8	4	40	8	14

contained dried bread, did not have any energy source and would cause deficiency of TDN (energy) in buffaloes producing more than 8 liters of milk as explained in Fig. 1. With low energy intake, significant part of the absorbed amino acids would partition for energy synthesis through gluconeogenesis in the liver. Proteins of the oil cakes and wheat bran were reported as highly soluble and the rumen degradability ranged from 73.25 to 89.73% (Habib *et al*., 1994) and therefore would supply little or no bypass protein. This will invariably produce large quantity of ammonia in the rumen. In the absence of adequate energy and minerals in the supplement, microbial population in the rumen would not efficiently utilize the resulting ammonia and the excess will be absorbed and converted to urea in the liver (Sarwar and Zia-ul-Hassan, 2001) and will ultimately be excreted in the urine.

Blood urea concentrations

Plasma urea concentrations of buffaloes during berseem and maize fodder seasons are illustrated in Fig. 2. The results varied among the farms ($P<0.05$) and seasons ($P<0.05$). Plasma urea levels were consistently higher (36.15 to 39.09 mg/100 ml) in all selected farms when the buffaloes received protein rich berseem together with the conventional concentrate supplement. When maize fodder served as the basal diet, plasma urea levels were relatively low (21.74 to 28.01 mg/100 ml), but still remained at the normal levels. The present findings support the results of Qureshi *et al.* (2002), who reported that plasma urea ranged from 30.97 to 46.00 mg/100 ml in dairy buffaloes. Elevated concentrations of plasma urea in the present buffaloes were presumably associated with feeding of large quantity of degradable protein (Broderick and Clayton, 1997). Recent findings of Shukat (2004) demonstrated that blood urea concentrations were positively related to

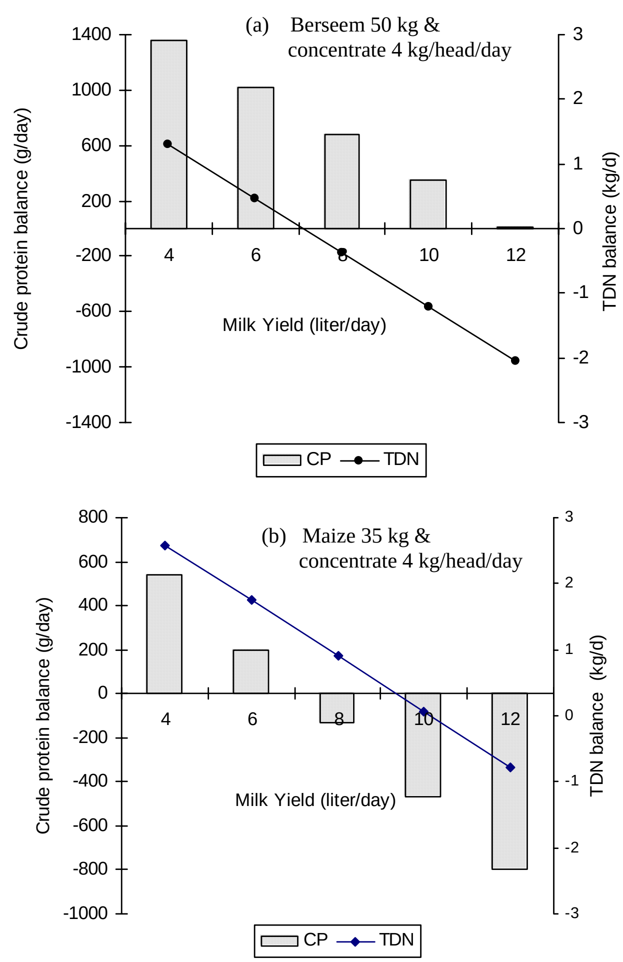

Fig. 1: Calculated TDN (energy) and crude protein (CP) balance in urban and periurban milking buffaloes with conventional feeding management during berseem season (a) or maize fodder season (b).

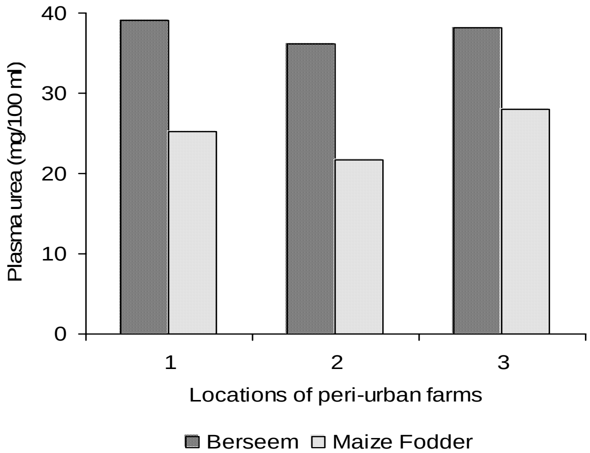

Fig. 2: Plasma urea concentrations in milking buffaloes during berseem and maize fodder seasons under conventional feeding management (each value is a mean of 15 observations recorded in five buffaloes of three randomly selected farms at three different locations).

crude protein intake in milking cows (R^2= 0.66). As discussed later, such high circulatory levels of urea have been widely advocated to adversely affect reproduction and health of the animals and also contribute to environmental pollution through excretion of large amounts of nitrogen by the animal.

Mineral deficiency and imbalances in conventional rations

No mineral source was included in the conventional farm prepared concentrate mixtures. Local farmers have yet to realize the importance of minerals feeding in dairy animals. Of particular significance was the deficiency of calcium in the conventional concentrate mixtures. As shown in Table 1, oil cakes and wheat bran were rich in phosphorus (1.00-1.40 g/100 g DM) and very low in calcium (0.13-0.23 g/100g DM) that resulted in imbalanced ratio of the two elements in the final mixtures (Table 2). It is thus obvious that feeding of these supplements would result in sub-optimum utilization of calcium and phosphorus in the animals, especially when fed with non leguminous fodders such as maize, sorghum and mott grass. The situation is improved when berseem and other leguminous fodder, high in calcium contents, are fed. In contrast to the normal ratio of calcium and phosphorus as 1:1-2:1 (NRC, 2001), the imbalanced feeding of these minerals under conventional feeding could be related to increased incidence of health disorders (milk fever, haemoglobinuria and paralytic disorders), infertility and reproductive problems (delayed estrus, repeated estrus, low conception, retained placenta and prolapsed uteri) together with low milk production (Underwood and Suttle, 1999; Qureshi *et al*., 1999; Habib *et al*., 2004).

Feeding management

Maize and berseem are two most common fodders preferred by local farmers for feeding buffaloes. Other sources to a lesser extent include sorghum, sugarcane tops, mott grass, oats and barley. Generally, 30 to 50 kg green fodder is daily fed to individual buffalo. Wheat straw invariably constitutes significant part of dairy ration and varies from 4 to 6 kg /head/day. During lean period, daily allowance of green fodder is reduced to about 10-15 kg and that of wheat straw is increased to above 8 kg as gut filler.

As a part of the traditional feeding system, all milking buffaloes in a farm are given fixed allowance of concentrate (4 to 6 kg/head/day) without taking into account their relative daily milk production capacity. This is apparently practiced for easy management and saving labour. As illustrated in Figure 3, such feeding practice deprives the potential high milk producers and on the other hand overburdens the low producers with nutrients like protein. When the quantity of concentrate given as a fixed allowance was calculated on the basis of per liter milk produced (Fig. 3), it was found that the buffaloes producing 10-12 liter milk/day received less concentrate (1-1.5 kg/liter), while low producers with 4-6 liter/day consumed 2 to 3.5 kg/liter. This anomaly can be corrected by grouping the buffaloes according to milk yield and feeding each group as one kg concentrate for every 2 liters milk. This will not only reduce the cost of feeding but will increase total daily milk produced at the farm.

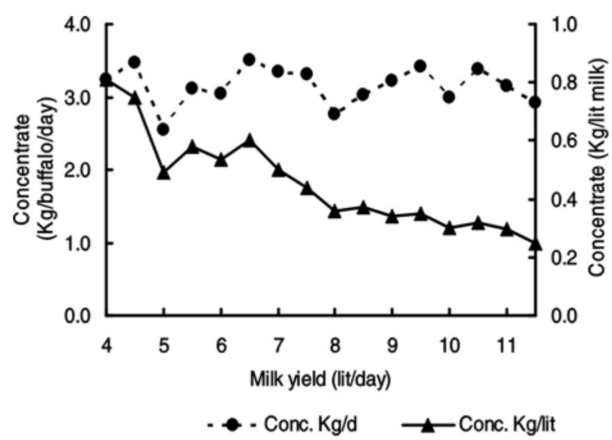

Fig. 3: Conventional feeding of fixed quantity of concentrate (kg/day) when calculated as kg/liter milk deprives the buffaloes producing more milk.

Availability of protein and energy (TDN) from two typical summer and winter dairy rations practiced in the local urban and peri-urban buffalo farms were calculated in relation to animal's requirements. These relationships are illustrated in Figure 1 which explains large inconsistency of protein and energy supply in milking buffaloes. During summer, when maize fodder was offered, buffaloes producing 10 liter or more milk per day suffered from both protein and energy deficiency. During winter when leguminous fodder (berseem) was fed, protein supply was not deficient but inadequate energy turned to be the major limiting factor in buffaloes producing 8 liter or more milk per day. In both fodder seasons, low milk producers (4-6 liter/day) consistently received both protein and energy in excess with the extent that protein intake reached to a maximum level of 900-1400 g/day above the requirement.

The above situation analysis foresees two major nutritional problems i) limited energy and protein supply impede productivity in high potential buffaloes and ii) extra nutrient supply in low producers add to feed cost without substantial increase in milk yield and adversely affect fertility and health of the animals.

As discussed earlier, energy sources such as cereals albeit dried bread are seldom added and the concentrate mixtures are predominantly based on proteinacious byproducts feeds that are highly degradable in the rumen and have low bypass protein quality. The quantity of absorbable protein from these conventional concentrate mixtures would be low and inadequate to meet the requirements for high milk production because the animals would mainly depend on microbial protein as a source of amino acids in the intestine (NRC, 2001). Rumen degradability of protein has become one of the most significant parameters in the new feed evaluation system for ruminants. Both ARC (1980) and NRC (2001) reported that even with maximum rumen efficiency, the quantity of microbial protein flowing small intestine might not be adequate to meet the needs for high milk producing cows. This is true because there is an upper limit beyond which synthesis of microbial protein per kg of organic matter fermented in the rumen cannot be increased (ARC, 1980). To correct the situation and meet requirement of metabolizable protein of high producing buffaloes and reduce ammonia burden, it is important to substitute some of the conventional soluble protein feeds (oil cakes) with undegradable feeds such as oil meals of vegetable or animal origin.

Reproduction and health disorders with imbalanced diet

Judging the conventional feeding system on protein degradability basis, two major nutritional issues can be raised. Firstly, due to high degradability of conventional feed, the requirement of high producing buffaloes for metabolizable protein are not adequately met. Secondly, high ammonia resulting from excessive feeding of fermentable protein would cause fertility and health problems. Evidence is available in the literature that suggest high blood urea resulting from excessive rumen ammonia reduces fertility through altering uterine environment, lowering LH and progesterone secretion through acting on pituitary ovarian axis and adversely affects immune system (Ferguson and Chalupa, 1989). Moreover, higher demand of ATP for urea synthesis from ammonia and amino acids in the liver reduces the overall efficiency of energy utilization in the animal body (Sarwar and Zia-ul Hassan, 2001).

Earlier studies in this laboratory performed with peri-urban buffaloes (Qureshi *et al*., 2002) reported that high blood urea concentrations were associated with delayed estrous resumption after parturition (R^2= 0.71) and low pregnancy rates (R^2= 0.91). These problems were more pronounced in buffaloes having blood urea higher than 31.01 mg/100 ml. This would suggest that in the preset study blood urea levels in the buffaloes as shown in Figure 2 were above this critical level when berseem was fed as a basal diet. This is because berseem is not only rich in crude protein (20-28 g/100g DM) but its proteins are highly fermentable and the rumen degradability ranges from 0.05 to 0.07 per hour (FAO, 1998). Other workers reported high incidence of retained placenta and metritis with elevated blood urea levels (Ferguson and Chalupa, 1989). All these problems associated with protein over burden and imbalanced feeding cause enormous economic losses in dairy farming.

Environmental aspects of imbalanced nutrition

Excessive feeding of soluble protein and phosphorus to buffaloes increases excretion of nitrogen and phosphorus in faeces and urine that directly contribute to environmental pollution. Ammonia vaporization from excreta adds to air pollution. Excessive nitrogen and phosphorus losses cause pollution of surface and ground water. Run off and leaching of nitrogen and phosphate into ground water directly leads to eutrophication and biodiversity losses in aquatic ecosystem. Similarly, nitrates in ground water cause human health hazards (Winfried, 1999). Disposal of animal excreta in urban and peri-urban farms always remain a problem due to limited space and inadequate arrangements for use. Excessive surface loading of limited soil with manure affects plant growth through toxic levels of nitrogen, phosphorus and potassium. It is assumed that with the existing conventional feeding of buffaloes in urban and peri-urban farms, more than 70% dietary nitrogen would be excreted by the animals. It can be calculated that with the existing conventional feeding regime, a buffalo would daily excrete 0.25 to 0.41 kg nitrogen in urine. This comes to a total of 25 to 41 kg nitrogen daily voided through urine in a dairy farm having 100 buffaloes. Such alarming amount of nitrogen added daily to atmosphere together with large amount of methane resulting from imbalanced feeding has large environmental concern (Leng, 1991). Moreover, excretion of nitrogen in urine resulting from excess consumption of dietary nitrogen entails high energy cost. Sarwar and Zia-ul Hassan (2001) calculated that energy cost of excreting 100 g nitrogen in urine is about 4.1 MJ. This would reduce the over all efficiency of energy utilization in animal body.

Future outlook

A two-pronged approach is required to correct the delivery of nutrients to milking buffaloes. Firstly, soluble protein in concentrate mixture for high producers should be partially replaced with undegradable protein sources. Locally available byproduct feeds need screening for rumen degradability to find less expensive suitable protein sources. Such information on national level is not available. Ingredient composition of concentrate mixture with respect to protein degradability and minerals should match the quality of basal fodder. Secondly, buffaloes should be fed according to their milk yield. Grouping of animals on the basis of milk production can facilitate delivery of correct allowance of concentrate mixture to animals.

Berseem and other leguminous cultivated fodders are rich in soluble protein. Reducing wasteful fermentation of nitrogen in such fodders through tannins association is another potential area that deserves research through collaboration of plant breeders and animal nutritionists. Medium levels of condensed tannins in plants protect protein against rumen degradation through hydrogen bondings that are reversible in acidic environment postruminally, thus shifting protein digestion and absorption to abomasum and small intestine that improves animal performance (Makkar, 2003). Whatever nutritional intervention is made in conventional feeding system to reduce nutrient losses in buffaloes, it must not allow the rumen fermentation to suffer rather should be complementary to nutrients output from rumen for enhancing productivity. Maximizing rumen efficiency to utilize fiberous feeds and non-protein nitrogen sources coupled with supplying bypass nutrients that avoid rumen fermentation should be the future goal of feeding high yielding buffaloes.

It is also important to evolve a useful indicator for judging the protein status of buffaloes. Feeding adjustment then can be applied to correct the situation for enhancing the efficiency of nutrient utilization for increased productivity. Recent studies with dairy cows in this laboratory (Shukat, 2004) and those reported by Broderick and Clayton (1997) concluded that milk urea concentrations can be used to predict the circulatory levels of plasma urea and protein intake in dairy cows. However, similar investigations are required in buffaloes. Recent work in this laboratory (unpublished) has shown that blood urea levels were higher in buffaloes than cows with the same levels of protein intake, indicating that in buffaloes feeding soluble protein may provoke higher circulatory levels of urea. However, normal threshold above which urea levels in buffaloes may be harmful is yet to be determined.

REFERENCES

AOAC, 1990. Official Methods of Analysis. 15th Ed., Association of Official Analytical Chemists, Washington, DC, USA.

ARC, 1980, Agricultural Research Council. The Nutrient Requirements of Ruminant Livestock. Commonwealth Agriculture Bureau, Farnham Royal, Slough, UK.

Agriculture Statistics of Pakistan, 2003. Ministry of Food, Agriculture and Livestock. (Economic Wing), Government of Pakistan, Islamabad, Pakistan.

Broderick, G. A. and M. K. Clayton, 1997. A statistical evaluation of animal and nutritional factors influencing concentration of milk urea nitrogen. J. Dairy. Sci., 80: 2964-2971.

Economic Survey of Pakistan, 2005-06. Government of Pakistan, Finance Division, Economic Advisor's Wing, Islamabad, Pakistan.

FAO, 1998. Tropical Feeds. Electronic Version 8. FAO, Rome, Italy.

FAO, 2003. Food and Agriculture Organization of United Nations, FAO Statistical Database, Rome, Italy.

Ferguson, J. D. and W. Chalupa, 1989. Impact of protein nutrition on reproduction in dairy cows. J. Dairy Sci., 72: 746-752.

Garcia, O., K. Mahmood and T. Hemme, 2003. A review of milk production in Pakistan with particular emphasis on small scale producers. Pro-poor Livestock Policy Initiative Working Paper No. 3, FAO, Rome.

Habib, G., M. Salim, M. Ajmal and Ghufranullah, 1994. Comparative degradability of proteins in the rumen of buffalo and cattle steers. In: Proc. IV World Buffalo Cong., 27-30 June, Sao Paulo, Brazil.

Habib, G., G. Jabbar, M. M. Siddiqui and Z. Shah, 2004. Paralytic disorders associated with phosphorus deficiency in buffaloes. Pakistan Vet. J., 24(1): 18-22.

Leng, R. A., 1991. Improving ruminant production and reducing methane emissions from ruminants by strategic supplementation. Publication of US Environmental Protection Agency (EPA/400/1-91/004), USA.

Makkar, H. P. S., 2003. Quantification of Tannins in Tree and Shrub Foliage. A Laboratory Mannual. Kluwer Academic Publishers, London, UK.

NRC, 2001. Nutrient Requirements of Dairy Animals. 7th Ed., National Research Council, National Academy Press, Washington, DC, USA.

Qureshi, M. S., M. M. Siddiqui, S. Khattak, G. Habib, H. A. Samad, H. A. Shamroz and N. Bano, 1999. Reproductive-nutrition interaction in dairy buffaloes. III. Effect of macro minerals intake and blood profile. Egyptian J. Dairy Sci., 28(1): 109-119.

Qureshi, M. S., G. Habib, H. A. Samad, M. M. Siddiqui, N. Ahmad and M. Syed, 2002. Reproduction-nutrition relationship in dairy buffaloes. 1. Effect of intake of protein, energy and blood metabolites levels. Asian-Aust. J. Anim. Sci., 15(3): 330-339

Richter, H. J. and M. Laponte, 1962. Diacetyl monoxime procedure of urea analysis. Clin. Chem., 15(8): 335-339.

Sarwar, M. and Zia-ul-Hassan, 2001. Nutrient Metabolism in Ruminants. University Press, Univ. Agri. Faisalabad, Pakistan.

SAS, 2001. SAS/STAT, User’s Guide, SAS Inst. Inc. Cary, NC, USA.

Shukat, A., 2004. Relationship of blood urea and milk urea nitrogen concentrations at different feeding, milk production levels and milking times in dairy cows with different protein intake. MSc (Hons) Thesis, NWFP Agri. Univ., Peshawar, Pakistan.

Underwood, E. J. and N. F. Suttle, 1999. The Mineral Nutrition of Livestock. 3rd Ed., CABI Publishing, New York, USA.

Winfried, S., 1999. Intensification of animal husbandry effect on global warming and soil quality. Anim. Res. Develop., 49: 8-13.