Effect of supplementation with protein differ for rumen degradability on milk production and nutrients utilization in early lactating Sahiwal cows

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Abstract

Early lactating Sahiwal cows (n=24) of approximately similar yield and lactation were selected and randomly divided into four groups of six cows in each. These groups were fed ad libitum four iso-energetic and iso-proteic diets with different rumen undegradable protein (RUP) sources: diet A 30% RUP, diet B 40% RUP, diet C 50% RUP and diet D 60% RUP in a completely randomized design. Among nutrients intake, dry matter (DM) and crude protein (CP) intake was significantly (P<0.01) different, while neutral detergent fibre (NDF) and acid detergent fibre (ADF) intakes were similar across four diets. DM, CP and NDF digestibility were also different (P<0.05) except, NDF digestibility. Whole milk yield (kg/d) and 4% fat corrected milk (FCM) (kg/d), fat (g/d) and protein (g/d) was found maximum on diet B, followed by diet A. Not significant differences were found in fat, solid not fat (SNF), protein, lactose, salts and total solids percentage across all diet except SNF, lactose and salts percentages which were significantly lower (P<0.05) on diet D. Nitrogen intake, balance and utilization were statistically similar across all diets however, nitrogen excretion in milk (g/d and percentage of intake) and urine (percentage of intake) were significantly different across diets. Nitrogen intake and output varied (P<0.01) across all diets. Nitrogen balance and its utilization were maximum (P<0.001) on diet B, while other diets showed not significant differences among themselves. Based on presenting findings, it is concluded that feed intake, digestibility and production performance was maximum in early lactating Sahiwal cows when fed 40% rumen undegradable protein in total mixed ration based diet.

Introduction

Pakistan stands among the leading milk producing countries of the world. Nili-Ravi buffalo and Sahiwal cow are the major milk producing dairy animals of Pakistan. Cows are 35.6 million of heads and share 16,133 thousand tons to the total milk (46,440) produced in the country (Government of Pakistan, 2011). Although, it is far less than buffaloes, yet this share is constantly increasing since last few years. However, production per dairy animal in Pakistan is far less than recognized dairy cattle breeds of the world. Sahiwal cow is the major dairy cattle breed of Pakistan and has inherent specialities of heat and tick resistance. Despite of some promising qualities in Sahiwal cattle breed, scientific research in evaluating nutritional requirements to maximize yield is still deficient.

In Pakistan, dairy animals are fed on rations based on conventional systems of energy and protein. This system does not consider the requirements of metabolizable protein need of early lactating and rapidly growing animals. The new concept of balancing crude protein for Rumen degradable protein (RDP) and rumen undegradable protein (RUP) is not known in Pakistan. The RDP is utilized for microbial growth while RUP remained inert in rumen and digested in small intestine form higher yield (Kamalak et al., 2005). It is reported that lactating and young growing animals fed on high RDP can not give its optimum performance due to high demand for RUP at that physiological status of animal (Habib, 2009). Kaischeur et al. (2006) also reported that ruminal undegradable protein needs to be supplement when microbial protein synthesis alone is insufficient to meet the metabolizable protein requirements in dairy animals especially during early lactation. When there is an increase in the dietary rumen undegradable protein milk yield increases (Gulati et al., 2005; Garg et al., 2007; Habib, 2009). Lack of response in milk yield, milk fat and protein on increasing RUP % in diets is also reported (Chritensen et al., 1993). The higher RDP than requirements of rumen microbes results in wastage of expensive part of diet and also decreases the RUP for efficient utilization in small intestine for more yields (Reynal and Broderick, 2003).

Materials and methods

Study was carried out at the Government Livestock Farm, Kallurkot, Pakistan. Description of the work is given under.

Twenty-four multiparous early lactating (17±88 days) Sahiwal cows were selected and randomly divided into four groups in a completely randomized design. Each group was of approximately similar milk yield and lactation. This experiment lasted for 103 days in which first fifteen days given to experimental animals for adaptation to their respective diets while, remaining period (90 days) used for data collection. All animals of each group were...
housed, tied and fed ad libitum in mangers having separate arrangement. Rations were offered daily at 9:00 am to their respective groups. Left feed was weighed, recorded and discarded before offering fresh weighed rations. Animals were milked twice a day at 2:00 am and 2:00 pm. Representative samples of feed offered, feed left and milk were taken daily and pooled for individual animals of each group.

Total mixed ration (TMR) was prepared having protein of different rumen degradable and undegradable ratios (Table 1) for each group. In particular, rations A, B, C and D contained 30, 40, 50 and 60% (RUP) of total crude protein, respectively. Ration B served as control group having 60:40 (RDP:RUP) ratios as recommended for large dairy cattle breeds (NRC, 2001). All TMR were iso-caloric and iso-nitrogenous (NRC, 2001). For the preparation of rations 3 and 4, rapeseed meal was treated with formaldehyde solution (1 g formaldehyde/100 gram crude protein) as suggested in the findings of Faran and Pasha (2000). In ration-4, corn gluten meal 60% was subjected to heat treatment for 1 h at 150°C. Treatment for 1 h at 150°C, corn gluten meal 60% was subjected to heat treatment for 1 h at 150°C, corn gluten meal 60% was subjected to heat treatment for 1 h at 150°C, corn gluten meal 60% was subjected to heat treatment for 1 h at 150°C with formaldehyde solution (1 g formaldehyde/100 gram crude protein) as suggested in the findings of Faran and Pasha (2000). All TMR were iso-caloric and iso-nitrogenous (NRC, 2001). Mathematical model is given as under:

\[ Y_{ij} = \mu + \tau_i + \epsilon_{ij} \]

where: 

- \( Y_{ij} \): each observation on \( i^\text{th} \) treatment due to \( j^\text{th} \) animal 
- \( \mu \): overall mean 
- \( \tau_i \): effect of \( i^\text{th} \) treatment (\( \sum \tau_i = 0 \) and \( i = 1, 2, 3 \)) 
- \( \epsilon_{ij} \): random error associated with \( i^\text{th} \) treatment and \( j^\text{th} \) animal with the restriction that variance \( \sigma^2 \) and mean zero.

\begin{table}[!h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
Ration & Ration 1 & Ration 2 & Ration 3 & Ration 4 \\
\hline
Ingredients & & & & \\
Wheat straw, % & 29 & 30 & 31 & 32 \\
Wheat bran, % & 22.4 & 16 & 20 & 15 \\
Molasses, % & 07 & 05 & 08 & 11 \\
Rice polishing, % & 09 & 05 & 01 & 06 \\
Rapeseed meal, % & 02 & 07 & 05 & - \\
Rapeseed meal (FT), % & - & - & 07 & - \\
Sunflower meal, % & 02 & 09 & 07 & 03 \\
Soybean meal, % & 06 & 04 & 01 & 02 \\
Cotton seed cake, % & 08 & 09 & 09 & 08 \\
Blood meal, % & - & - & 04 & 04 \\
Urea, % & 0.6 & - & - & - \\
Mineral mixture% & 02 & 02 & 02 & 02 \\
Chemical composition & & & & \\
DM, % & 91.11 & 90.20 & 91.75 & 89.78 \\
ME, Mcal/kg & 2.35 & 2.35 & 2.36 & 2.36 \\
CF, % & 17.01 & 17.29 & 17.24 & 16.99 \\
NDF, % & 38.2 & 38.1 & 38.5 & 39.9 \\
ADF, % & 22.3 & 21.8 & 22.3 & 22.9 \\
RUP (% CP) (kp=5%) & 5.26 & 6.80 & 8.67 & 10.39 \\
RDP: RUP & 69:31 & 61:39 & 50:50 & 39:61 \\
\hline
\end{tabular}
\caption{Ingredients (%) and chemical composition of experimental total mixed rations fed to early lactating Sahiwal cows.}
\end{table}

Results and discussion

Nutrients intake and utilization

Nutrients intake in Sahiwal cows fed rations varying in rumen degradability of protein (Table 2) showed significant differences in dry matter and crude protein intakes in these rations \((P<0.01)\), whereas NDF and ADF intakes were statistically similar \((P>0.05)\) in all diets. DM intake was maximum in diets B and A, while minimum in diets C and D. Although, DM intake in diets B and A was statistically similar \((P>0.05)\), an increasing tendency was observed with increase in RUP from 30% (diet A) to 40% (diet B). However, this tendency decreased \((P>0.01)\) with further increase in RUP proportion in other diets (C, 50% and D, 60%). Nevertheless, comparatively...
higher dry matter intake on diets B and A suggests efficient rumen fermentation due to availability of proper proportion of rumen degradable protein for microbial need which may have resulted in increased DM intake. It is also assumed that rumen degradable part provides nitrogen in diversified form for microbial growth, which led to improved rumen environment and hence, increases feed intake (Delcurto et al., 1990).

The influence of degradability nature of diets showed more pronounced tendency (P<0.01) in CP intake as diet B>A>C>D. This trend of CP intake is due to almost similar trend of DM intake on these respective diets. These results are partly according to Blackwelder et al. (1998) who reported increased CP intake due to increased DM intake. Further, level of protein degradability in different rations showed any influence (P>0.05) on NDF and ADF intakes in experimental groups.

Significant differences were found in DM, CP and NDF digestibility, while ADF digestibility remained unaltered across all diets. DM digestibility increased (P<0.05) with increasing RUP proportion in diet, the highest value was found in 40% RUP diet which decreased with further increase in RUP% in diets (C and D). These results suggest that 60% RDP (B) in diets may have provided adequate ammonia N for microbial growth, which might have improved rumen fermentation and DM digestibility. Further increase in RDP level may decrease RUP percentage in small intestine, while any decrease in RDP level may influence microbial growth and DM digestibility. CP digestibility was also different among experimental diets (P<0.001). Although statistically similar, diet B (40% RUP) showed maximum CP digestibility compared with diet A (30% RUP), while further increase in RUP% in diets C and D decreased (P<0.001) CP digestibility. This last result suggest low availability of ammonia N for rumen microbes due to their increased RUP proportions which in turn may have resulted in reduced microbial synthesis and, hence, digestion. Earlier findings (Kowalczyk et al., 1993) also reported decreased CP digestibility with increased RUP% in diets. NDF digestibility showed similar tendency as diet B showed maximum (P<0.05) digestibility followed in diet A and minimum in diets C and D. The increased NDF digestibility on diet B suggests maximum and efficient microbial growth on these RDP and RUP proportions in early lactating Sahiwal cows. ADF digestibility remained the same across all the diets, which explains that different RUP proportion in experimental diets has no effect on ADF utilization. Winsryg et al. (1991) also reported similar effects on ADF digestibility using protein sources of different rumen degradability.

**Milk yield and composition**

Results showed that varying protein degradability in experimental diets had significant effects (P<0.001) on production performance of early lactating Sahiwal cows (Table 3). Yield trend in these diets are presented in Figure 1. Milk yield (kg/d) increased with increase in RUP proportion up to 40% (B), however it significantly declined with further increase in RUP to either 50% (C) or 60 % (D). It followed similar trend in 4% fat corrected milk (FCM), even if, the 4% FCM yield was statistically similar to diets B and A. The higher milk yield on diet B and declining tendency on other diets was directly proportional to dry matter intake. It followed the general concept that maximizing DM intake (through better feeding strategy) in early lactating cows leads to higher peak yield. These results also explain that diet B (40% RUP, 60% RDP) not only provided adequate ammonia N for microbial synthesis but also fulfilled animal’s amino acid requirement in intestine for enhanced milk yield. The lack of response on diets A, C and D partly explains the imbalance in RDP and RUP proportions in diets for the need of rumen microbes and availability in intestine for milk synthesis. Habib (2009) reported that increasing the levels of rumen degradable protein in diets of dairy animals does not always enhance milk yield due to limited supply of metabolizable protein. On the other hand, supplying more than adequate RUP proportion in diets limits carbohydrate digestion and VFA production, which in turn affects animal’s production performance.

Milk composition (i.e., fat, protein and total solids) was statistically similar in all diets. The solid not fat (SNF), lactose and salts contents...
were also similar among diets A, B and C, however, diet D showed significantly (P<0.05) lower value for these contents (Table 3). These results can explain inefficient production of rumen microbes in this diet, which in turn affected efficient digestion and absorption for milk synthesis. The lack of statistical difference in fat, protein and total solids with increase in RUP percentage in diets is in line with earlier studies: Balckwelder et al. (1998) observed any effect of RUP supplementation on milk composition. Similarly, Schroeder and Gagliostro (2001) reported non-significant differences in milk fat, protein and lactose percentage on RUP diets in early lactating cows. In milk components yield (g/d), fat and protein yields were significantly different (P<0.001). Protein yield was high on diet having the maximum milk yield (B) while it was lowest on diet having the lowest milk yield (D). Fat yield also followed the same pattern, however, due to comparatively higher fat percentage on diet A than B, produced statistically similar fat yield on both diets.

Nitrogen balance

Nitrogen intake, excretion, balance and utilization in early lactating Sahiwal cows fed rations varying in protein degradability are given in Table 4. Nitrogen intake was significantly different among different diets (P<0.01). However, the difference between diet B and A were not significant (P>0.05). The difference in nitrogen intake in early lactating Sahiwal cows is due to difference in dry matter intake, which followed similar trend. In nitrogen output, faecal excretion was statistically unaffected by RUP percentage in diets, however it was significantly affected as per cent of N intake. It was highest (P<0.001) on maximum RUP percentage in diets, i.e. diet D, followed by diet C and lowest (P<0.001) on minimum RUP percentage in diets, i.e. A and B. Similarly to our findings, Lines and Weiss (1996) reported increase in faecal N output with increased RUP% in diets. These results of faecal out put also suggest the efficiency of RUP percentage in experimental diets, i.e. the more faecal N excretion, the less the efficiency of respective diets in terms of production and utilization. In urinary N output (g/d) significant differences (P<0.01) were observed in different experimental diets, however, as per cent of N intake it was statistically similar (P>0.05). Urinary N excretion (g/d) was maximum (P<0.01) on low RUP diets (A and B), while lowest on high RUP percentage diets (C and D). These results suggest that diets with higher RUP percentage have a tendency towards lower N excretion. Accordingly, diet A, 30% RUP, diet B, 40% RUP, diet C, 50% RUP, diet D, 60% RUP, *Nitrogen balance: N intake – N output (faecal N + urinary N + milk N); **means with different superscripts within same row are significantly different (P<0.05); *P<0.05; **P<0.01; ***P<0.001, ns, not significant (P>0.05).

Castillo et al. (2001) found increased urinary N excretion on diets having more RDP. N excretion through milk as g/d was affected (P<0.05) by diets and was maximum on 40% RUP (diet B) followed by 30% RUP (diet A), while minimum on 50% and 60% RUP diets. This trend of milk N excretion is based on milk yield on different diets and i.e. diets yielded more milk caused more N to flow for the protein synthesis in milk. Nitrogen balance as g/d or percent of N intake was significantly (P<0.001) different on experimental diets. It followed the trend as diet B >A> C and D. These results suggest that N was more efficiently utilized on diet B (60% RDP: 40% RUP), which stimulated maximum microbial growth and flow of undegraded protein to intestine and caused minimum N excretion through faeces. Comparatively, low N balance on higher RUP diets (C and D) was due to maximum N excretion through faeces on these diets, which may be due to low microbial growth which consequently reduced digestibility. In N utilization, all diets performed statistically similar (P>0.05) except diet B, which may be due to high N balance on this diet, i.e. due to comparatively less faecal N excretion and almost similar milk N output.

Conclusions

Effect of protein supplements having different rumen degradability characteristics (30, 40, 50 and 60% RUP) influenced nutrients intake, digestibility and yield performance during early lactation in Sahiwal cows. DM intake, digestibility, milk yield, nitrogen balance and utilization was maximum in Diet B (40% RUP) however, diet A (30% RUP) produced similar influence in DM intake and digestibility. No improvement in yield observed with further increase in RUP percentage in diets. This study confirms the recommendations of NRC (2001) for RDP and RUP requirements of early lactating cows NRC (2001).
Studies on different lactation phases in native dairy cattle and buffaloes are fertile areas of further research.

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