Journal of Cleaner Production 177 (2018) 655–664

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Rice gluten meal, an agro-industrial by-product, supports performance attributes in lactating Murrah buffaloes (*Bubalus bubalis*)

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ARTICLE INFO

Article history:
Available online 28 December 2017

Keywords:
Blood composition
Buffalo nutrition
Corn gluten meal
Efficiency
Milk production
Rice gluten meal

ABSTRACT

Alternative feedstuffs having potential to deliver nutrients without inflicting zoo-technical attributes would be of great interest for today's livestock industry that aims at cleaner, greener and environmentally-steward production. In this perspective, we investigated the effect of partial substitution of customarily used protein feed peanut cake (PNC) by either rice gluten meal (RGM) or corn gluten meal (CGM) in compound feed mixture (CFM) on milk performance of Murrah buffaloes. Eighteen buffaloes in early lactation were divided into three similar groups and fed a basal diet comprising of chopped green corn, wheat straw and CFM. Control group received CFM containing mainly PNC as protein source, while it was replaced by 50% of RGM and CGM isonitrogenously in T1 and T2, respectively, for 120 days including a seven-day metabolism trial.

Results revealed a lack of effect of treatments on intake and digestibility of nutrients as well as plane of nutrition. Furthermore, yields of milk, milk components and milk energy output were higher ($P < 0.01$) in T2 with similar milk composition and milk energy content across the groups. Nevertheless, feed efficiency was improved ($P < 0.05$) in group T2 with higher ($P < 0.01$) nitrogen (N) balance and apparently metabolized N. However, no effect was elicited on calculated methane emission and energy balance. Urea-N concentration in milk and plasma decreased ($P < 0.01$) in T2 with no discernible influence on other plasma metabolites. It was concluded that RGM supports the same production at 50% replacement of PNC, and at similar level, CGM resulted in even better response for lactating buffalo diets supporting resource-efficient and economic buffalo production.

1. Introduction

The worldwide-anticipated dairy consumption is reported to escalate by 0.58 in 2050 and the associated feed production to underpin this demand would be a challenge for achieving precision dairy nutrition targeting cleaner and sustainable livestock production (Makkar, 2016; Kholif et al., 2017). Consequently, global demand for alternative feed ingredients have risen sharply in the recent past, owing partly to the exorbitant prices of traditional raw materials as well as volatility in feed markets. Indian dairy industry largely relies upon buffaloes to the extent of 56% of total national milk grid. However, the existing situation of dearth of protein feedstuffs to the extent of 47% (NIANP, 2013), reinforces further search for strengthening country's feed balance. In this context, wet milling manufacture of starch from cereal grains produces endosperm protein-rich by (co)-products called gluten meals (Heuzé et al., 2015). Corn gluten meal (CGM), obtained at the rate of 3–5% from corn wet milling, contains

Abbreviations: ADF, acid detergent fiber; ADIN, acid detergent insoluble nitrogen; ADL, acid detergent lignin; ANOVA, analysis of variance; ALT, alanine aminotransaminase; AA, amino acid; NH_3, ammonia; ApDN, apparently digested N; ADOM, apparently digested organic matter; apMN, apparently metabolized N; AST, aspartate aminotransaminase; BW, body weight; CFM, concentrate feed mixture; CGM, corn gluten meal; CP, crude protein; DM, dry matter; DMI, dry matter intake; EMNS, efficiency of microbial nitrogen synthesis; ECM, energy-corrected milk; EAA, essential AA; EE, ether extract; FCM, fat-corrected milk; FRAP, ferric reducing antioxidant power; IADP, intestinally absorbable dietary protein; Ig, Immunoglobulin; IPD, intestinal protein digestion; ME, metabolizable energy; MNS, microbial nitrogen synthesis; MUN, milk urea nitrogen; NE, net energy; NE_L, net energy for lactation; NE_M, netenergy for maintenance; NDF, neutral detergent fiber; N, nitrogen; NEAA, non-essential AA; NEFA, non-esterified fatty acids; DMAB, p-dimethylaminobenzaldehyde; PNC, peanut cake; PUN, plasma urea nitrogen; PD, purine derivatives; RFI, residual feed intake; RGM, rice gluten meal; RDP, rumen degradable protein; RUP, rumen undegradable protein; SBM, soybean meal; TDN, total digestible nutrients.

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https://doi.org/10.1016/j.jclepro.2017.12.206
0959-6526/

60–70% of crude protein (CP), rich in carotenoid xanthophylls and thus studied extensively as protein source in ruminants like lactating cows (Wohlt et al., 1991; Filho et al., 2009; Aboozar and Niazi, 2013; Chandrasekharaiah et al., 2017), buffaloes (Nisa et al., 2008), small ruminants (Tufarelli et al., 2009), among others. In addition to its rich rumen undegradable protein (RUP) fraction, CGM is also a good source of sulfur containing amino acid methionine (Nisa et al., 2008; Heuzé et al., 2015).

More recently, industrial extraction of starch from rice (*Oryza sativa*) is growing in India and as a result, rice gluten meal (RGM) is produced as a by-product thereof. Unlike CGM, RGM has brownish color with much lower CP (40–47% on dry basis) value (Kumar et al., 2016; Mahesh et al., 2017; Malik et al., 2017). Until today, there is no well-documented competitive usage of RGM, except as animal feed. It is highly imperative to generate detailed information on alternative feed ingredients before introducing them into dairy ration (Makkar, 2016), and currently, no literature could be traced that compared the nutritive worth of RGM with CGM in lactation diets. Therefore, it would be logical to compare these two feedstuffs originated from similar wet-milling processes and thus, we hypothesized that isonitrogenous substitution of traditional protein feed peanut cake (PNC) by RGM and CGM benefits lactational performance of buffaloes.

Off late, the burgeoning environmental stewardship has strongly entailed livestock operations to curtail enteric emission of greenhouse gases particularly methane (CH_4) as well as manure nutrient excretions while also performing life cycle assessment (Patra, 2017a). Hence, strategies abating these pollutants could contribute toward cleaner, greener and sustainable livestock production (Eisler et al., 2014; Kholif et al., 2017). Despite these awareness, the published studies on this aspect in tropical buffaloes are limited (Garg et al., 2013), and particularly with gluten meals, are scarce.

Considering the above facts, the main objectives were set to investigate the influence of isonitrogenous substitution of PNC by RGM and CGM, each at 50% levels in the concentrate feed mixture (CFM) on feed utilization, milk production, energy and protein metabolism as well as related blood constituents in early lactating Murrah buffaloes.

2. Materials and methods

2.1. Ethical compliance

Experimental protocol including handling and management of animals were done in compliance with appropriate laws and guidelines laid down by the Institutional Animal Ethics Committee constituted under CPCSEA, New Delhi, MoEFCC, Government of India. This study took place over four months in fall during 25th June to 24th October, 2014 with daily minimum and maximum temperatures averaging 5 °C and 20 °C, respectively.

2.2. Buffaloes, feeding, management and experimental design

Eighteen early lactating Murrah buffaloes were selected and enrolled for this study by dividing into three similar groups of six each based on comparable body weight (BW: 589 ± 9.73 kg), parity (2.1 ± 0.21), days in milk (69.7 ± 8.22) and milk yield (9.61 ± 0.30 kg) in a randomized block design. The buffaloes were identified by numbered ear tags, tethered with iron chain individually and housed in a well-ventilated experimental shed having adequate access to sun light. The brick floor was disinfected using diluted phenyl solution twice weekly. Buffaloes were protected from heat stress by splashing tap water four times a day and allowed wallowing for half an hour, once a week. Before commencing experimental feeding *per se*, ten days of adaptation was given, during which all buffaloes were dewormed orally (Fenbendazole at 5 mg/kg BW) and empty BW, daily dry matter (DM) intake (DMI) as well as milk yield were noted for subsequent grouping.

All buffaloes were fed a diet consisting of green corn forage (*Zea mays*, African Tall variety, harvested at mid-bloom stage and chopped to 2–3 cm length), wheat (*Triticum aestivum*) straw (threshed to 1–2 cm length) and isonitrogenous CFM in the form of coarse mash at the rate of 0.5 of milk yield, maintaining an approximate forage to concentrate ratio of 68:32. Buffaloes in first group (control) were provided a CFM containing mainly peanut cake (PNC), whereas in second (T1) and third group (T2), 50% nitrogen (N) of PNC was replaced by RGM and CGM, respectively. Thus, on physical basis, the levels of PNC, RGM and CGM in three CFM were 300, 140 and 100 g/kg, respectively (Table 1). Feeding arrangement comprised of two separate mangers per buffalo with no headlocks, one for green forage and another for CFM mixed with wheat straw. Freshly harvested green forage was offered twice daily i.e., in the morning (1000 h) and evening (1900 h) with hourly push-up within the manger avoiding fermentative heat-up and thus maximizing voluntary intake. The CFM was offered during milking time (0500 h and 1700 h) and also with wheat straw (0900 h). All the feedstuffs, on individual animal basis, were weighed using spring balance before feeding to meet complete nutrient requirements (ICAR, 2013) for a total period of 120 days. Orts that was approximately <10% of total DM offered, were weighed the next morning and oven-dried (100 °C for 24 h) to determine daily DMI. The ration was adjusted commensurate with milk yield and moisture content of forage, every weekly. Clean and fresh drinking water was made available four times a day.

2.3. Metabolism trial and nutrient digestibility

After 80 days of experimental feeding, all buffaloes were shifted to metabolism cages for a seven-day metabolism trial. A brief period of two days adaptation was given within cages followed by seven days of collection. Quantitative data on intake of feeds (corn green forage, wheat straw and CFM), orts, and daily voidance of urine and feces were collected in a total collection method. For urine collection, the cages were fitted with two plastic cans (10 L capacity) previously rinsed with 5 mL of 250 mL/L H_2SO_4 thereby avoiding volatile losses of ammoniacal nitrogen (N). Similarly, feces was collected immediately after defecation and stored in closed plastic bucket until next morning. Maximum precaution was ensured to prevent inter-mixing of urine and feces, and most of the times, kept the cages in dry condition. The suitable aliquots of feces (1/200 for DM and 1/1000 for N) and urine (1/400 for N) sampled daily were preserved in polypropylene bottles containing 25 mL of 250 mL/L H_2SO_4 and pooled over for seven days separately for each buffalo. About 5 g of wet feces and 10 mL of urine of properly mixed and pooled samples were subjected for N estimation by Kjeldahl method.

Based on quantitative intake of particular nutrient and its fecal excretion, apparent coefficient of digestibility was computed, which was used for expressing total digestible nutrient (TDN) value of diets. Further, metabolizable energy (ME) was obtained upon multiplying TDN by 0.15 such that 1 kg of TDN equaled 15.13 MJ of ME (NRC, 2001). In addition, N balance was calculated by subtracting fecal, urinary and milk N from dietary N intake. Net energy (NE) balance was worked out as follows (NRC, 2001; Nisa et al., 2008):

$$\text{NE balance (MJ)} = [\text{DMI (kg)} \times \text{NE}_L(\text{MJ})] - (0.08 \times \text{BW}^{0.75}) - [\text{Milk (kg)} \times \{(41.63 \times \text{fat \%}) + (24.13 \times \text{protein \%}) + (21.60 \times \text{lactose \%}) - 11.72\} \times 2.2 \div 1000 \times 4.184]$$