ISSN 0970-3209
ISSN 2231-6744 (online)

JUNE 2019 | VOL. 36 | #2

INDIAN JOURNAL OF ANIMAL NUTRITION

I J A N

AN OFFICIAL PUBLICATION OF
ANIMAL NUTRITION SOCIETY OF INDIA
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INDIAN JOURNAL OF ANIMAL NUTRITION

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ACKNOWLEDGEMENT

Animal Nutrition Society of India puts on record its sincere thanks to Indian Council of Agricultural Research, New Delhi for grant of financial support for publication of IJAN

INDIAN JOURNAL OF ANIMAL NUTRITION
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Indian J. Anim. Nutr. 2019. 36 (2): 107-112
doi: 10.5958/2231-6744.2019.00020.3

Indian Journal of Animal Nutrition

REVIEW

Effect of Dietary Plant Secondary Metabolites on Rumen Fermentation and Microbial Community: A Review

P.S. Banakar, Srobana Sarkar, Bhawna Tyagi, V.V. Vinay, Timmi Chugh, Sachin Kumar, Nitin Tyagi and A.K. Tyagi*

Rumen Biotechnology Lab, Animal Nutrition Division, ICAR- National Dairy Research Institute, Karnal-132001, Haryana, India

ABSTRACT

Plants are a significant source of novel medicinal products and secondary metabolites are a distinctive source of pharmaceutical food additives, flavours and other industrial commodities. These plant secondary metabolites are found to manipulate rumen fermentation process by altering the population of microbial community. Changes in microbial population has further aided in limiting the biohydrogenation process of fatty acids and production of methane. Biohydrgenation of the ingested fatty acids results in saturated fatty acids produced at the cost of unsaturated fatty acids. Animal science advocates are trying various feasible approaches to influence ruminal biohydrogenation processes to achieve ruminant-derived products with reduced saturated fatty acids quantity, which would be of significant value to the wellness of consumers. Dose dependent action of plant secondary metabolites on rumen microbes is not completely investigated. Under the present scenario it would be most apt to explore the potentials of phytochemicals as modulators of ruminal biohydrogenation vis-a-vis most other supplements, such as oil or oil-rich grains.

Keywords: Biohydrogenation, Methane, Plant secondary metabolites, Rumen microbes

INTRODUCTION

At the moment "one health concept" has drawn attention given that, it is an integrative effort of various disciplines working locally, nationally, and globally to attain optimal health for people, animals, and the environment. Scientists, research institutes, food and pharmaceutical industries around the globe are fine tuning their research to identify new sources of natural compounds with fascinating properties that can replace antibiotics or synthetic compounds to improve feed efficiency and promote livestock growth without compromising on the safety of end consumers. Plant secondary metabolites (PSM) such as tannins, saponins and polyphenols are now being extensively studied for their ability to manipulate the rumen fermentation and thereby influencing the performance of animals and the composition of meat and milk products (Wallace, 2007). Manipulation of rumen fermentation depends on the sources and dosage of secondary metabolites in the animal diet. Research reports suggest that at suitable doses, PSM suppresses protozoal populations, increases bacterial and fungal populations, propionate production, microbial yield and decreases methanogenesis to improve the productive performance in ruminants and this change in the fermentation pattern are mainly attributed to their antimicrobial and antioxidant activity that could help to maintain the animal health. Even though ruminant's diets are rich in poly unsaturated fatty acids (PUFA), their products such as meat, milk and milk products contain mainly saturated fatty acids (SFA) because of the extensive biohydrogenation of ingested PUFA in the rumen.

Modification of the biohydrogenation process plays key role in getting better fatty acid profile in animal products (Durmic *et al.,* 2008; Vasta *et al.,* 2008). This could be achieved either by modifying the rumen environment, changing the competition among different microbial populations during fermentation, augment or reduce specific microbial populations, or target biohydrogenating enzymes through dietary

*Corresponding author: amrishtyagi@1963yahoo.com

manipulation by using feed additives (Khiaosa-Ard *et al.,* 2009).

PLANT SECONDARY METABOLITES AS FEED ADDITIVES

The activity and concentration of phytochemicals in crops is affected by geographic places with varying weather conditions, year-round collection time, sample handling and storage (Bodas *et al.,* 2008). These phytogenic feed additives modify ruminal fatty acid biohydrogenation by exerting antimicrobial effect on biohydrogenating organisms in the rumen (Durmic *et al.,* 2008), accumulating beneficial intermediates (Vasta *et al.,* 2008) and manipulating multiple enzymes engaged in biohydrogenation (Miri *et al.,* 2015), thereby influencing the fatty acid profile of milk and meat. Miri *et al.* (2015) noted that cumin (*Cuminum cyminum*) seed extract (CSE) supplementation increased CLA ruminal concentration by 34.8% and Vaccinic acid (VA) by 11.4%, along with the synchronized rise in CLA and linolenic acid concentration and decline in goat milk stearic acid content. Similar outcomes were recorded in ewes grazing sulla (CT: 2.6% DM) with or without PEG supplementation, where Ruminic acid and VA were smaller, whereas C18:2 n6 and C18:3 n3 were greater than ewes milk receiving sulla + PEG in sulla-fed milk (Cabiddu *et al.,* 2009). However, most research on plant secondary metabolites (PSM) and ruminal bio-hydrogenation were performed through *in vitro* research, while the literature's *in vivo* works are limited.

PSM SUPPLEMETATION ON RUMEN FERMENTATION

PSM and Rumen Biohydrogenation

Recently, phytogenic feed additives have been a major interest of research among ruminant nutritionist. The phytochemicals or PSM are groups of chemical compounds in plants that are not primarily involved in the primary biochemical processes such as plant growth, development and reproduction. These PSM in plants produce a line of defense which ensures survival of the plant structures and reproductive elements by protecting against insect predation. Earlier, these PSM were considered as anti-nutritional factors in animal nutrition because of their antibacterial properties and adverse effects on nutrient utilization. However, recent researches have shown that plant secondary metabolites have potential to modify rumen fermentation favourably, at a relatively low concentration. At appropriate doses, phytobiotics, have suppressed protozoal populations, increased bacterial and fungal populations, propionate production, microbial yield, and decreased methanogenesis to improve the productive performance in ruminants (Hristov *et al.,* 1999; Patra *et al.* 2006; Benchaar *et al.* 2007). Lately, the phytogenic feed additives rich in secondary metabolites are being studied thoroughly with an aim to improve the fatty acid profile in milk and meat by manipulating the process of rumen biohydrogenation.

In vitro incubation of tropical (Jayanegara *et al.,* 2011) and alpine plants (Jayanegara *et al.,* 2012) with additional linseed oil suggest the ability of plant phenolics in modulating fatty acid biohydrogenation by decelerating the process right from the first step. This was indicated by lower disappearance of C18:3 n3 and C18:2 n6 in the incubations of both tropical and alpine plants containing high phenolics in the respective studies. In relation to ruminal biohydrogenation of fatty acids, tannins have been reported to reduce PUFA biohydrogenation, accumulate *trans-11* C18:1, decrease concentration of C18:0 (Jayanegara *et al.,* 2012) and increase the transfer rate of C18:3 n3 from feed to milk (Kalber *et al.,* 2011).

Cabiddu *et al*. (2010) observed a negative relationship between tannins (present in *Vicia sativa* and *Trifolium incarnatum)* and biohydrogenation of C18:3 n-3, appearance of C18:0 and positive correlation of appearance of C18:2 *cis*-9 *trans*-11 *in vitro*. Furthermore, Khiaosa-ard *et al.* (2009) in an *in vitro* study observed a considerable increase of *trans-11* C18:1 at the expense of C18:0 in rumen fluid by adding *Acacia mearnsii* extract (source of CT) at 79 g/kg DM to a grass-clover hay diet supplemented with linseed oil and concluded that tannins inhibited the terminal step of FA biohydrogenation. Also Durmic *et al.* (2008) reported that when extracts from *Acacia iteaphylla* (containing condensed tannins) were incubated *in vitro* with sheep ruminal fluid the production of VA increased while SA

decreased.

Addition of *Chrysanthemum coronarium* (@ 5 mg/reaction) and LA to sheep rumen digesta under *in vitro* conditions inhibited ruminal biohydrogenation due to active principle coronaric acid, resulting in increased accumulation of VA with subsequent reduction in stearic acid (Wood *et al.,* 2010). Smilarly, Vasta *et al.* (2009) studied the effects of extracted tannins from carob (*Ceratonia siliqua*), acacia leaves (*Acacia cyanophylla*) and quebracho (*Schinopsis lorentzii*) on *in vitro* rumen biohydrogenation of cow rumen fluid incubated with hay as a substrate. Three concentrations of tannins were added to the substrate (0·0, 0·6 and 1·0 mg/ml RF). In tannin-containing fermenters, vaccenic acid was accumulated (23%) while stearic acid was reduced (16%) and concentration of total conjugated linoleic acid isomers and linoleic acid isomerase (LA-I) activity (nmol CLA produced/min per mg protein) was not affected by tannins.

Lourenco *et al.* (2009) also observed that essential oils rich in monoterpenes (limonene and carvone) resulted in the accumulation of *cis-9, trans-11* CLA in ruminal fluid. Miri *et al.* (2015) reported that dietary supplementation of (*Cuminum cyminum*) seed extract (CSE) in goats (at 1.27% and 2.53% of dry matter intake) increased the ruminal concentration of CLA (C18:2 *cis-9, trans-11*) by 34.8% and VA (C18:1 *trans-11*) by 11.4% in lower supplemented group as compared to CSE free diet. Furthermore, in the same study linoleate isomerase activity (LA-I) of the only stearate forming bacterium, *B. proteoclasticus* was decreased by 53% in the presence of the CSE (4.25 g CSE/ml).

PSM and biohydrogenating microbes

The effect of plant extracts or its secondary metabolites on biohydrogenating bacterial species are variable and it depends on the nature of the plant secondary metabolites. Studies on pure cultures of bacteria showed that *Yucca schidigera* extract (1% v/v) inhibited the growth of *B. fibrisolvens* and *Streptococcus bovis,* while the growth of *Prevotella ruminicola* was increased and the growth of *Selenomonas ruminantium* Z108 was unaffected (Wallace *et al.* 1994). Sivakumaran *et al.* (2004) found that proanthocyanidins fractions from *Dorycnium* with high molecular weight inhibited the growth of *B. fibrisolvens* CF3, while low molecular weight fractions did not interfere with bacterial growth.

Some plant extracts and essential oils from Australian plants have been reported to have a selective inhibitory effect on *B. proteoclasticus* without affecting *Butyrivibrio fibrisolvens,* and some can inhibit the saturation of C18:2 n6, cis-9, trans-11 C18:2 and t11 C18:1 *in vitro* (Durmic *et al.* 2008). Wood *et al.* (2010) observed that addition of *Chrysanthemum coronarium* to pure culture of *B. proteoclasticus* (stearate forming bacteria) inhibited its growth. Furthermore, *C. coronarium* also reduced the rate of LA metabolism. Vasta *et al.* (2010) reported that supplementation of tannins in sheep increased the total protozoa and the relative abundance of *B. fibrisolvens* and decreased the relative abundance of *B. proteoclasticus* in the rumen. Ruminal infusion of garlic oil (GO, 0.8 g/d) in rumen of wethers reduced the relative abundance of *Butyrivibrio proteoclasticus* whereas, GO has no effect on the population of *Butyrivibrio* group of bacteria (Zhu *et al.* 2012). Moreover, defaunation by other compounds also increased some *Butyrivibrio spp.* (Karnati *et al.* 2009). Jafari *et al.* (2016) observed that supplementation of papaya leaves extract (methanolic) at concentrations of 5, 10 and 15 mg/250mg dry matter (DM) reduced the population density of *B. fibrisolvens* as compared to control in buffered rumen fluid after 24h incubation.

PSM and methane production

Manipulation of rumen fermentation is desired to enhance the digestibility of low-quality feed, decrease the production of methane, acetate propionate ratio to enhance animal feed use and decrease greenhouse gas concerns. To accomplish these objectives, the use of plant extracts as feed additives is a favourable choice. Tropical plants or their extracts have a wide variety of secondary metabolites such as saponins, tannins and essential oils (Patra and Saxena, 2009). Plants comprising large quantities of saponins can reduce methane by inhibiting or eliminating protozoa from the

rumen (Newbold *et al.,* 1997; Kamra *et al.,* 2000, Goel *et al.* 2008).

Tannins have also been observed to decrease the output of methane, although their efficiency depends on the type and amount of secondary metabolite (Hess *et al.,* 2003; Patra *et al.,* 2008). Plant extracts with elevated flavonoids decreased the production of methane and enhanced microbial biomass owing to enhanced degradability of organic matter (Broudiscou *et al.,* 2002). The reduction in methane is likely due to either a decrease in protozoal numbers and/or methanogenic archaea. Supplementation of saponin, from *Yucca schidigera* plant up to 77 ppm of feed reduced protozoal numbers, and increased bacterial population and organic matter digestion *in vitro* continuous culture systems (Valdez *et al.,* 1986).

Patra *et al.* (2006) assessed the impacts of *Acacia concinna* (Shikakai), seed pulp of *Terminalia chebula* (harad), *Terminalia belerica* (bahera), *Emblica officinalis* (amla) and seed kernel of *Azadirachta indica* (neem seed) extracts in various solvents (ethanol, methanol and water) on methane production and rumen fermentation in *in vitro* gas production tests. Among the extracts, methanolic extract of *T. chebula* suppressed *in vitro* methane production. Total volatile fatty acids (TVFA) were reduced with extracts of *T. chebula* and *A. indica*. Furthermore, *in vitro* dry matter and organic matter degradabilities of feed (g/g) were reduced with all the extracts as compared to the control. A study by Agarwal *et al.* (2008) found a dose-dependent anti-protozoal and anti-methanogenic activity of peppermint oil and eucalyptus oil, with the largest rate of peppermint oil (150 ìl/30 ml of incubation medium) reducing the output of methane by 93 % relative to control.

Methanogenesis inhibition was followed by a significant reduction in feed degradability and production of volatile fatty acids. Incubation of tea saponin (TS) at concentrations of 0, 2, 4, 6 and 8 mg versus 200 mg of corn meal and grass meal (1/1, w / w) in rumen fluid boosted the production of gas and microbial biomass with subsequent decrease in methane, ammonia nitrogen and protozoa. However, concentration of total and individual volatile fatty acids remained unchanged with tea saponins (Hu *et al.,* 2005). Patra *et al.* (2006) conducted an *in vitro* experiment with spices that showed (P<0.05) reduction in methane emission by adding ethanol and methanol extracts of fennel, clove and garlic and observed maximum inhibition (83%) with methanol extract of clove. Further, there was an increase in gas production along with total volatile fatty acid with the addition of garlic and clove extracts. Likewise, Kim *et al.,* (2012) studied the effects of plant extracts (wormwood, garlic, onion, ginger, mandarin orange, honeysuckle) on *in vitro* methanogenesis and rumen microbial diversity. Total gas production was the highest for ginger extract, whereas, methane (ml / g DM) was the highest for control, but lowest for garlic extract. With the addition of plant extracts, the concentration of VFAs and pH were not impacted. Howover, in the garlic and ginger extracts, the ratio of acetate to propionate was lower than that of the control.

Tan *et al.* (2011) performed a test using various proportions of purified condensed tannins (CT) obtained from *Leucaena leucocephala* hybrid-Rendang (LLR) for their impacts on *in vitro* fermentation. For *in vitro* gas production technique, purified CT levels of 0 (control), 10, 15, 20, 25 and 30 mg were used. Total gas (ml / g DM) and VFA concentration (mmol/l) decreased at a decreasing rate with increased CT inclusions. Kim *et al.* (2016) observed that *in vitro* incubation of *Arisaema ringens* extract with buffered rumen liquor reduced methane production by more than 43 %, increased TVFA concentration without a change in ruminal pH and digestibility of dry matter.

CONCLUSIONS

Studies reviewed here show that plant secondary metabolites influence the profile of meat and milk fatty acids through modulation of ruminal biohydrogenation. It would be more appropriate to use phytobiotics as modulators of ruminal biohydrogenation than most other supplements, such as oil or oil-rich grains. Plant secondary metabolites appear to have an anti-methanogenic activity and defaunating properties, favoring lower methane production. Contradictory

findings on depression in digestibility of organic matter require further studies to evaluate the ideal amount of supplementation of secondary plant metabolites that enable the production of methane to be mitigated without compromising animal performance.

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Received on 04-06-2019 and accepted on 20-06-2019

Indian J. Anim. Nutr. 2019. 36 (2): 113-121
doi: 10.5958/2231-6744.2019.00021.5

Indian Journal of Animal Nutrition

Growth Performance, Feed Efficiency and Ingestive Behavior of Sahiwal Calves Divergently Selected for Residual Feed Intake

Anil Kumar Singh, Muneendra Kumar*, Vinod Kumar, Debashis Roy, Raju Kushwaha, Shalini Vaswani and Avinash Kumar

Department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, U.P. Pt. Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan, Mathura-281001, Uttar Pradesh, India

ABSTRACT

This study aimed to evaluate differences in performance, feed utilization efficiency, and ingestive behavior between low and high residual feed intake (RFI) growing cattle. Eighteen growing female Sahiwal calves (age 10±4 months,body weight 100±45 kg) were fed individually using *ad libitum* feeding of total mixed ration for a period of 90 days. RFI varied from -0.53 to 0.40 kg dry matter (DM)/day with a mean RFI of -0.27 to 0.17 kg DM/day in low and high RFI calves, respectively. Significant (P<0.001) differences between low and high RFI calves were observed for daily DM intake (DMI). Calves with low RFI consumed 26% less DM compared to high RFI group yet gaining at similar rate. Low RFI calves needed 35% less metabolizable energy for body maintenance (MEm) compared to high RFI calves while metabolizable energy for gain (MEg) was similar among both groups. Low RFI calves digested feed more efficiently than high RFI calves. Low RFI calves were also more efficient in feed conversion, feed efficiency, Kleiber ratio (KR), and relative growth rate (RGR) than high RFI calves. Low RFI calves consumed less feed than high RFI calves, therefore, spent less time in feeding, rumination, and chewing. RFI was positively correlated with DMI, MEm and MEg and gain while negatively correlated with traditional feed efficiency measures and ingestive behavior. This study suggests that low RFI calves are more efficient because they eat less and require less energy for physical activity and feeding pattern.

Keywords: Efficiency, Ingestive behavior, Performance, Residual feed intake, Sahiwal calves

INTRODUCTION

India harbors world's largest cattle population and ranked first in milk production in the world. In spite of achieving the highest milk production, the performance of Indian cattle has been extremely poor and the average milk productivity per milch cow falls far below that what has been achieved by the developed countries. Poor performance of indigenous cattle is due to older age at maturity, thus, they consume larger amount of feed before attaining sexual maturity. Feed cost for maintenance is estimated to represent at least 60 to 65% of the total feed requirements for the cow herd with considerable variation among individual animals independent of body size (NIANP, 2013). Improving feed utilization efficiency and selection of energetically efficient animals could help in reducing the burden of already scarce feed resources particularly in developing countries (Nkrumah *et al.,* 2006).

Earlier, genetic selection programs have focused on production traits with lesser attention given to production costs. Recently, this view begun to change and the efficiency of conversion of feed has been recognized as more important tool.Several measures of feed utilization efficiency calculated as a function of individual intake and body weight gain have been proposed over the years in an attempt to quantify the capacity of animals to convert the ingested feed into a product. Selection based on traditional measures like feed conversion ratio (FCR) and feed conversion efficiency (FCE) is most common, but these measured ratios are closely associated with feed intake and rate of gain (Koots *et al.,* 1994a) which may result in higher mature body weight that may not be desirable under many circumstances (Archer *et al.,* 1998).Therefore, residual feed intake (RFI) was introduced as an alternate measure of feed efficiency. The RFI referred

*Corresponding author: E-mail: muneendra82@gmail.com

to as net feed intake or net feed efficiency and it is defined as the difference between actual feed intake and predicted feed intake on the basis of requirements for maintenance and current level of production (Koch *et al.,* 1963). It has been found that more efficient cattle (low RFI) have multiple benefits such as decreased feed intake, less manure production, and less methane emission (Nkrumah *et al.,* 2006; Hegarty *et al.,* 2007; Kuldeep Dudi *et al.,* 2016; Negesse *et al.,* 2016).

The biological basis that contribute to the variation in RFI includes, ingestive behavior, feed intake, digestion of feed and associated energy use, metabolism, including anabolism and catabolism, activity and thermoregulation (Nguyen *et al.,* 2005). The RFI tended to be correlated with apparent digestibility of nutrients and animals with low RFI had higher nutrients digestibility compared to animals with high RFI. Low and high RFI animals differ in their feeding pattern, a fact that is mainly due to differences in amount of feed ingested and in rumination time.The identification of low RFI farm animals and ultimately using them for breed improvement programme can go a long way in attaining the objectives of breed improvement and efficient nutrient utilization. Considering these facts, the present study is designed to investigate the performance of dairy calves divergently selected for low and high RFI. The hypothesis of the present study is that RFI is related to feed efficiency and performance and difference exist between calves with divergent RFI.

MATERIALS AND METHODS

The use of the animals and the experimental procedure was approved by the Institutional Animal Ethics Committee (IAEC) constituted as per the article number 13 of the Committee for the Purpose of Control and Supervision on Experiments on Animals (CPCSEA) rules, laid down by the Government of India (approval no. 110/ IAEC/16).

Eighteen growing female Sahiwal calves (Av. age = 4 months, BW=100 kg) were selected from the herd maintained at Instructional Livestock Farm Complex (ILFC), DUVASU, Mathura, India. All the experimental calves were fed *ad lib* on total mixed ration (TMR) based diet consisted of concentrate mixture: green oat fodder: wheat straw in the proportion of 50: 20: 30 (on DM basis) for a period of 90 days based on the recommendations of Archer *et al.* (1997) for the optimum test duration for measuring RFI.The compounded concentrate consisted of 20 parts barley grain, 20 parts wheat grain, 8 parts gram chuni, 20 parts wheat bran, 30 parts mustard oil cake (expeller extracted) and 2 parts mineral mixture. The TMR was prepared daily by hand mixing separately for each calf. TMR contained 14.80% CP, 46.70% TDN and 2.33 Mcal ME/kg DM (Table 1). The calves were fed TMR in such an amount that at least 1 kg refusals were left daily per calf. All experimental calves were housed in a well ventilated shed having proper arrangements for individual animal feeding. One daily meal of TMR was offered at 09:00 h to each calf. Fresh drinking water was offered *ad lib* twice daily at 08:00 h and 17:00 h. Deworming of all the experimental animals was done before the start of the experiment by oral administration of Fentas bolus (Intas Pharmaceuticals Pvt. Ltd., India).

To compare the efficiency of nutrient utilisation in low and high RFI calves, a digestion trial with an adaptation period of 4 days followed by a collection period of 6 days was conducted at the end of the study. TMR offered and refusal left were sampled daily for chemical analysis. Faces excreted during 24 h were collected and measured daily for 6 days. 1/100 part of thoroughly mixed total faecal matter was taken for chemical analysis. Daily, 1% of total faecal sample was collected separately and stored in plastic containers having 30 ml of 25% sulphuric acid solution for nitrogen (N) estimation.

All experimental calves were monitored daily for DMI and fortnightly for growth performance, feed efficiency measures and ingestive behavior.Feed offered and refusal left were weighed daily, sampled twice per week, and pooled to represent each period of 90 days for DM determination. DMI was calculated as the difference between the amount offered and refusal left. To increase the accuracy of estimation of average daily gain (ADG), calves were weighed at fortnight intervals

in early morning (06:00h) before offering feed and water. Along with RFI, calves were also monitored fortnightly for other feed efficiency measures like FCR (feed-to-gain-ratio), FCE (gain-to-feed-ratio), Kleiber ratio (KR), partial efficiency of growth (PEG), and relative growth rate (RGR). FCR was calculated as the ratio among DMI and ADG; FCE was calculated as the ratio between ADG and DMI. KR was calculated as the ratio between ADG and average metabolic body weight, and PEG was calculated as the ratio between ADG per unit of feed used for growth (NRC, 2001). RGR was calculated according to Fitzhugh and Taylor (1971):

$$RGR = 100 \times \frac{(\log \text{Final BW} - \log \text{Initial BW})}{\text{days of experiment}}$$

At mid of study, ingestive behavior was determined by monitoring calves for feeding, chewing, rumination, idleness, standing and lying. The behavioral events were recorded manually by four observers, each of them responsible for a daily period of 6 h. Feeding time (FT; min/d) was counted as total time spend by calf in consuming TMR during 24 h. Three rumen boluses per calf were observed during rumination and the number and time of chewing per bolus was counted as chewing rate (CT). Rumination time (RT) was total time during 24 h in which calf ruminated. Time spent on idleness (TI) was calculated by deducting duration of events (min/d) with total duration of day (1440 min). To determine the time of activity spent with the diet (min/kg DM) like feeding time per kg DM (FTDM), rumination time per kg DM (RTDM) and chewing time per kg DM (CTDM), total duration of the activities was divided by the total amount of feed consumed.

ADG was determined by using linear regression coefficient of weights as a function of days in trial

Table 1. Ingredient and chemical composition of TMR fed during experimental period (expressed as g/kg of DM)

Item	Concentrate	TMR
Oat fodder		200
Wheat straw		300
Concentrate		500
Barley grain	200	
Wheat grain	200	
Gram chuni	80	
Wheat bran	200	
Mustard oil cake	300	
Mineral mixture	20	
Chemical composition of TMR (g/kg DM)		
Dry matter	556	
Organic matter	918	
Crude protein	148	
Total ash	92	
Ether extract	32.7	
Crude fibre	325	
Nitrogen free extract	392.3	
Neutral detergent fibre	653.2	
Acid detergent fibre	391.1	
Acid detergent lignin	67.5	
Total digestible nutrient	467	
Metabolizable energy (Mcal/kg DM)	2.33	

TMR, total mixed ration; ME, metabolizable energy (calculated as per NRC, 2001)

following Archer *et al.* (1997):

$$y_i = \alpha + \beta \times DIT_i + e_i$$

Where, y_i is the calves' bodyweight in the i^{th} observation, α is the intercept of the regression equation corresponding to the initial body weight, β is the linear regression coefficient corresponding to ADG, DITi is the days in trial in the i^{th} observation and e_i is the random error. Mid-test metabolic body weight (MBW) was calculated by using following equation:

$$MBW = [\alpha + \beta \times \text{study period}/2]^{0.75}$$

Where, α is the intercept of the regression equation corresponding to the initial body weight and β is the linear regression coefficient corresponding to ADG. Calves were classified into low and high RFI groups. RFI was calculated by using the following formula:

RFI (kg/d)=Actual DMI (kg/d)–Predicted DMI (kg/d)

The amounts of DM offered and refusal left were measured daily and the actual DMI was calculated by difference. Predicted DMI of individual calf was calculated by using multiple regression models:

$$Y_j = \beta_0 + \beta_1 MBWj + \beta_2 ADGj + e_j$$

Where, Y_j is the predicted DMI of the j^{th} animal, β_0 is the regression intercept, β_1 is the regression coefficient on MBW, β_2 is the regression coefficient on ADG, e_j is the uncontrolled error of the j^{th} animal. Observed and required MEm and MEg were calculated by following equations:

MEI observed (Mcal/d)=DMI ×ME of feed

Where, MEI is the metabolizable energy intake.

MEm observed (Mcal/d) = MEI observed – MEg observed

$$MEm \text{ required (Mcal/d)} = 122 \times BW^{0.75}/1000$$

$$MEg \text{ observed (Mcal/d)} = (4.1 + 0.0332 \times W - 0.000009 \times W^2)) / (1 - 0.1475 \times WG)$$

Where, W is the live weight (kg) and WG is the live weight gain (kg/d).

MEg required (Mcal/d) = MEI required –MEm required

The representative samples of TMR offered, residues left and faeces (collected during digestion trial) were dried in a hot air oven at 60°C till a constant weight was attained and then ground in a Wiley mill to pass a 1 mm sieve. Dried and ground samples were pooled animal wise and stored at dry place for further analysis of DM, CP, ether extract and acid insoluble ash (AOAC, 2005). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to the procedures described by Van Soest*et al.* (1991).

The data were analysed for significance ($P<0.05$) and correlation coefficient (r) by using Statistical Package for the Social Sciences (SPSS for Windows, V21.0; SPSS Inc., Chicago, IL, USA). Significance was analysed by using one way analysis of variance (ANOVA). An alpha level of 0.05 was used for the determination of statistical significance.Greater or lower than zero value of Pearson square correlation coefficient shows positive or negative correlation between RFI and attributes, whereas, zero value of Pearson square correlation coefficient shows no correlation between RFI and attributes.

RESULTS AND DISCUSSION

Significant differences ($P<0.05$) between low and high RFI calves were observed for feed intake, low RFI calves consumed 26% less DM than calves of high RFI group (Table 2).Out of eighteen calves, the observed DMI of eleven calves was lower than the expected DMI (low RFI), whereas, that of remaining seven calves was higher than the expected DMI (high RFI) (Fig. 1). The difference in observed and required DMI (RFI) averaged 0.17 kg/day and -0.27 kg/day in low and high RFI groups, respectively.

The minimum and maximum values for RFI were -0.53 and 0.40 kg DM/day. The least efficient calf consumed 0.930 kg DM/day more feed than the most efficient calf. ADG was statistically similar among low and high RFI groups.In this study, positive correlation were observed among RFI and DMI ($r = 0.756$) while correlation with ADG ($r = 0.191$) was weak. On an average, low RFI calves consumed 26% less feed than high RFI calves, a value that agrees very well with the 19% differences in the Murrah buffalo calves divergently selected for low (-0.14 kg/day) and high RFI (0.14 kg/day) with no difference in body weight gain (Sharma *et al.,* 2016).Nascimento *et al.* (2015) noted that low RFI (≤0.128 kg/day) Nellore cattle consumed 7.2 kg DM/day which was 14.0% less than animals with

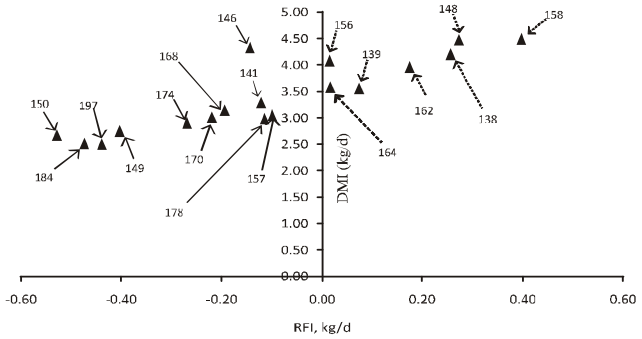

Fig. 1. Dry matter intake in low and high RFI Sahiwal calves

high RFI (>0.135 kg/day), although no significant differences in ADG were observed among RFI classes. The 10% reduction in DMI by the low RFI Murrah buffalo calves than high RFI (-0.20 *vs.* 0.23 kg DM/day) despite no differences in body weight gain was reported by Bose *et al.* (2014). Accordingly, no differences in ADG were detected between Sahiwal calves of low and high RFI despite the fact that high RFI calves consumed 19.6% more feed than low RFI calves (Sharma *et al.,* 2014). Results of low DMI in more efficient animals were also reported Bonilha *et al.* (2013), who found a difference of 0.656 kg/day between low and high RFI Nellore bulls with similar body size and growth rate. Fitzsimons *et al.* (2014) observed similar ADG among low and high RFI heifers (-0.43 *vs.* 0.44 kg/day) even though high RFI beef heifers consumed 16% more feed DM than low RFI heifers. Other studies also reported lower feed intake and similar growth rate in low RFI animals than high RFI animals (Sobrinho *et al.,* 2011; Steyn *et al.,* 2014). In this regard, Bonilha *et al.* (2013), Nascimento *et al.* (2015) and Sharma *et al.* (2016) reported a positive correlation between RFI and feed intake whereas the

Table 2. Intake and digestibility of nutrients in low and high RFI calves

Attribute	RFI		SEM	P-value$^{\beta}$	r$^{¥}$
	Low (-0.27)	High (0.17)			
Initial BW(kg)	85	114	5.64	0.003	0.652
Mid-test BW(kg)	108	137	5.89	0.028	0.659
Final BW(kg)	135	165	6.05	0.002	0.669
MBW(kg)	33.50	46.04	1.57	0.003	0.667
DMI (kg/d)	3.01^{a}	4.06^{b}	0.38	<0.001	0.756
DMI(kg/100 kg BW)	2.95	3.01	0.08	0.072	0.293
DCPI (kg/d)	0.348^{a}	0.456^{b}	0.03	0.002	0.673
ME intake observed (Mcal/d)	6.50^{a}	8.77^{b}	0.34	<0.001	0.756
MEm observed (Mcal/d)	4.09^{a}	6.28^{b}	0.30	<0.001	0.767
MEg observed (Mcal/d)	2.41	2.49	0.05	0.085	0.417
ADG (kg/d)	0.549	0.570	0.02	0.346	0.191
Apparent nutrient digestibility (g/kg DM)					
Dry matter	631	610	7.60	0.153	-0.351
Organic matter	678	664	4.62	0.398	-0.212
Crude protein	782	759	9.70	0.106	-0.393
Ether extract	918	896	6.30	0.319	-0.547
Neutral detergent fibre	587	580	13.2	0.721	-0.090
Acid detergent fibre	503	502	18.5	0.797	-0.007

$^{\beta}$Mean with different superscript in a row differs significantly (P< 0.05); $^{¥}$Pearson square correlation coefficient between RFI and attributes; RFI, residual feed intake; SEM, standard error of mean; BW, body weight; MBW, mid-test metabolic body weight; DMI, dry matter intake; DMIBW, dry matter intake in relation to body weight; DCPI, digestible crude protein intake (estimated during digestion trial); MEm, metabolizable energy for maintenance (as per NRC, 2001); MEg, metabolizable energy for gain; ADG, average daily gain

correlation between RFI and body weight gain was 0. A lower feed intake in more efficient calves without alteration in growth rate imply that these animals were more efficient in utilizing feed nutrients for tissue growth as a result of higher metabolizability of consumed feed.

The total ME intake observed and ME used for body maintenance (MEm) was significantly higher (P<0.001) in less efficient (high RFI) calves than more efficient (low RFI) calves (Table 2). Low RFI calves required 35% less MEm compared to high RFI despite no difference observed for MEg between both groups. Medium positive correlation were noted among RFI and MEm observed (r = 0.767) and MEg observed (r = 0.417). RFI takes into account the energy requirements for maintenance and production and is more sensitive to variations in energy efficiency of the individual animals (Dittmar, 2007). Sharma *et al.* (2016) observed 12.5 *vs.* 16.7 MJ/dayMEm and 7.5 *vs.* 7.9 MJ/dayMEg, respectively in low and high RFI Murrah buffalo calves which is in accordance with the findings of our study. Bose *et al.* (2014) have also reported that more efficient calves needed lower ME for body maintenance than the less efficient calves, whereas, ME required for gain was similar among two groups. Lower energy requirement for body maintenance in more efficient animals were also reported by Pitchford (2004) and Richardson and Herd (2004). Lower feed intake, high metabolizability of feed, and lower energy expenditure for feeding and rumination are some of the reasons that contribute to lower maintenance energy requirements in more efficient calves when compared to less efficient calves (Oddy and Herd, 2001). The differences in feed intake between animals could affect RFI status because increased feed intake is associated with increased energy expenditure towards digestion processes, thereby, increasing the maintenance requirement (Oddy and Herd, 2001). This could be due to an increased mass of digestive tissues, as the mass of digestive tissues increases, the metabolism of these tissues may be altered, reducing digestive efficiency.

Although the digestibility coefficients for majority of the nutrients were higher for low RFI group as

Table 3. Measures of feed efficiency and ingestive behavior in low and high RFI calves

Attribute	RFI		SEM	P-value[β]	r[¥]
	Low	High			
Feed efficiency measures					
RFI, kg DM/d	-0.27	0.17			
Feed conversion ratio	5.51[a]	7.28[b]	0.4	0.002	0.670
Feed conversion efficiency	0.20[b]	0.15[a]	0.01	0.002	-0.668
Kleiber ratio	0.02[b]	0.01[a]	0.001	0.004	-0.645
Relative growth rate	0.225[b]	0.105[a]	0.01	0.013	-0.575
Body condition score	2.55	2.75	0.17	0.153	0.351
Partial efficiency of growth	2.90	2.95	0.36	<0.001	0.019
Ingestive behavior (min/d)					
Feeding time	271.91	281.71	4.30	0.595	0.134
FTDM (min/kg DM)	92.38[b]	69.56[a]	3.93	0.006	-0.619
RTDM (min/kg DM)	55.65	44.97	9.37	0.137	-0.364
Chewing time	227.64	236,29	11.20	0.365	0.227
CTDM (min/kg DM)	77	58.35	5.19	0.238	-0.293
Time spent on idleness (min/d)	1004	980	10.50	0.357	-0.231

[β]Mean with different superscript in a row differs significantly (P< 0.05); [¥]Pearson square correlation coefficient; RFI, residual feed intake; SEM, standard error of mean; FTDM, feeding time kg^{-1} dry matter; RTDM, rumination time kg^{-1} dry matter; CTDM, chewing time kg^{-1} dry matter.

compared to the high RFI group but mean value showed non-significant differences between the groups (Table 2). The correlation between RFI and nutrient digestibility were weak to medium negative, *viz.* -0.351 with DM digestibility, -0.393 with CP digestibility and -0.090 with NDF digestibility. Nkrumah *et al.* (2006) observed 6% higher apparent digestibility of DM in low RFI group than high RFI group, indicating that animals with a low RFI are more efficient in nutrient utilization than with a high RFI. Richardson *et al.* (2001) observed digestibility estimates in growing cattle divergently selected for low and high RFI after one generation. When fed the roughage-based diets, low RFI bulls and heifers tended to have higher digestibility compared to the high RFI bulls and heifers. However, similar nutrient digestibility between low and high RFI animals were observed by Bose *et al.* (2014) and Sharma *et al.* (2016) which might be due to a closer variation in RFI among groups with low and high RFI. Variations in intake and digestibility could be attributed to the shift in rumen microbial community between efficient and inefficient animals (Guan *et al.,* 2008). There were significant differences in FCR (P=0.002), FCE (P=0.002), KR (P=0.004), RGR (P=0.013), and PEG (P<0.001) (Table 3).

Low RFI calves were 24% more efficient than high RFI calves in feed conversion, 25% more efficient in feed efficiency, 29% more efficient in the KR, and 31% more efficient in RGR. RFI showed negative correlation with FCE (*r*=-0.668), KR (*r*=-0.645), and RGR (*r*=-0.575) and positive correlation with FCR (*r*=0.670), PEG (*r*=0.019), and BCS (*r*=0.351).Low RFI animals showed greater residual weight gain, residual intake-weight gain, feed efficiency, and PEG as well as lower FCR than animals with medium and high RFI, respectively (Nascimento *et al.,* 2015). Earlier reports (Bose *et al.,* 2014; Sharma *et al.,* 2014; Sharma *et al.* 2016) also noted better FCR in low RFI animals than high RFI animals. Nkrumah *et al.* (2006) and Kayser and Hill (2013) obtained a difference of 18% and 17%, respectively in FCR between animals classified as low RFI and high RFI group. In contrast, Nkrumah *et al.* (2004) found that the two measures (PEG and RFI) were similar among low and high RFI groups. Kelly *et al.* (2014) observed negative correlation between RFI and FCE but not with ADG, KR, or RGR. A weak positive correlation of 0.12 between KR and RFI was estimated, as well as a strong negative correlation of -0.64 between KR and FCR (Steyn *et al.,* 2014). The correlation between RFI and FCR was estimated to be 0.67 which is similar to previously published estimates ranging from 0.57 to 0.85 (Nkrumah *et al.,* 2004; Van der Westhuizen *et al.,* 2004). Our findings also agree with these indicating that applying selection pressure for FCR or FCE would likely lead to an increase in mature size and thus an increase in maintenance energy and feed requirements.

Less efficient (high RFI) calves consumed more feed than more efficient (low RFI) calves (3.01 *vs.* 4.06 kg/day), therefore, spent more time in feeding (P=0.595), rumination (P=0.479) and chewing (P=0.365) (Table 3).Less efficient calves consumed 26% more feed and took 7.72% more time in feeding, 23% more time in rumination and 18% more time in chewing than more efficient calves. The time of activity spent with the diet i.e. FTDM and CTDM (min/kg DM) were significantly (P<0.05) higher in more efficient calves as compared to less efficient calves. More efficient calves spent more (P=0.357) time in resting (idleness) than less efficient calves. RFI showed positive correlation with FT (*r*=0.134), RT (*r*=0.178), and CT (*r*=0.227) while negative correlation with TI (*r*=-0.231). The correlation between RFI and time of activity spent with the diet was medium to high, including -0.619 with FTDM, -0.364 with RTDM and -0.293 with CTDM. The feeding behavior of animal can alter physical activity and thus influence total energy expenditure and feed efficiency (Susenbeth *et al.,* 1998). Similar to the findings of present study, Kelly *et al.* (2010a) found that high efficient animals spent less time and energy in this activity and more time in sedentary activities possibly saving energy that is directed towards weight gain. A shorter bunk visit duration in more efficient animals than less efficient animals was also noted by Lancaster *et al.* (2009) and McGee *et al.* (2014). High-efficiency animals used less energy in the physiological processes

involved in maintenance resulting in more net energy available for tissue accretion (Castro Bulle *et al.,* 2007). Kelly *et al.* (2014) observed positive relationships between feeding events and DMI (r = 0.31), ADG (r = 0.28), and RFI (r = 0.24), but not with gain: feed ratio in finishing heifers. In agreement, the present study observed a trend toward a positive relationship of RFI with both number of daily feeding events and eating rate. McGee *et al.* (2014), and Lancaster *et al.* (2009) reported a moderate correlation between RFI and bunk visit frequency (r = 0.29) and Kayser and Hill (2013) found a moderate correlation between RFI and DMI per visit in Angus (r = 0.52) and Hereford (r = 0.36) cattle.

CONCLUSION

Therefore, low RFI calves are more efficient because they consumed less feed, spent lesser time in feeding events and required less metabolizable energy for body maintenance.

ACKNOWLEDGEMENTS

Financial assistance for the research was provided under University Grant supported by Indian Council of Agricultural Research, New Delhi, India. We thanks to the Faculty and Staff of the Department of Animal Nutrition and Instructional Livestock Farm Complex, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India.

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Received on 29-03-2019 and accepted on 30-05-2019

Indian J. Anim. Nutr. 2019. 36 (2): 122-129
doi: 10.5958/2231-6744.2019.00022.7

Indian Journal of Animal Nutrition

Effect of Molasses Based Multi-nutrient Supplement Containing Chromium on Nutrient Utilization, Milk Yield, Microbial Protein Flow and Antioxidant Status of Lactating Murrah Buffaloes

A.K. Patil*, A.K. Verma, Putan Singh and Asit Das

ICAR-Indian Veterinary Research Institute, Bareilly, Uttar Pradesh-243122, India

ABSTRACT

The present experiment was conducted to study the effect of supplement of molasses based multi-nutrients containing chromium picolinate on nutrient utilization, milk yield, microbial protein flow and antioxidant status of lactating Murrah buffaloes. Twenty one lactating buffaloes were equally divided into three groups (n=7) on the basis of body weight (560±10.0 kg) and milk yield. Basal diet consisting of wheat straw, maize green and concentrate mixture was fed to all the groups. In addition of basal diet, the animals of group T_2 were fed 250 g molasses based multi-nutrients supplement (MMS-1) and the animals in group T_3 fed with 250 g MMS plus 5 mg Chromium Picolinate (MMS-2). The digestibility of the nutrients remained similar ($P>0.05$) among all the groups. Dietary MMS supplementation tended to improve milk yield by 18 and 16% in groups T_2 and T_3, respectively. The activities of superoxide dismutase, catalase and glutathione peroxidase were significantly ($P<0.05$) higher in both the supplemented groups, however, the mean value of glutathione reductase was similar in all three groups. It was observed that MMS supplementation did not have any significant effect on urinary excretion of allantoin, uric acid, purine derivative, creatinine and PDC index (mmol/l). From the results it can be concluded that supplementation of molasses based multi-nutrients (250 g/buffalo/day) improved milk yield by 18 (T_2) and 16 (T_3) percent and had better antioxidant status with comparable intake and digestibility of nutrients in lactating Murrah buffaloes.

Keywords: Cr-Picolinate, Milk Yield, Molasses, Multi nutrient supplementation, Murrah buffaloes, Nutrient utilization, Purine derivative index

INTRODUCTION

In our country, the buffalo mainly thrives on cereal straws that are highly lignified and have lower content of fermentable energy and protein, minerals and vitamins. Poor performance of buffaloes are mainly due to irregular and inadequate availability of quality feedstuff and imbalance of nutrients. Considering the availability and price of concentrate mixture, resource poor farmers can hardly afford them. Use of NPN substances like urea was tried earlier to replace the costly sources of proteins in ruminant diet. Feeding of molasses and urea is a suitable way of supplying fermentable energy and degradable protein, respectively. Urea molasses mineral supplement is an alternative feed resource that has been advocated as a panacea to protein and energy deficiency in ruminants especially during dry season (Aye, 2012). Number of on-station trials have been conducted in India and assessed the animal response and economic benefits of using UMMB (Srinivas and Gupta, 1997; Misra and Reddy, 2004) and results revealed that 30 to 40% of concentrate allowances could be reduced by feeding UMMB without any loss of milk production (Singh and Singh, 2003; Misra and Reddy, 2004). Mineral deficiency in grazing ruminants has been reported by several authors (Gowda *et al.,* 2004; Khan *et al.,* 2007) and supplementation is one way of tackling this problem. In an earlier study chromium was supplemented as it regulates carbohydrate metabolism as a structural component of glucose tolerance factor (GTF) (Mertz, 1993) which increases the absorption of glucose from circulation into peripheral tissues. In India, studies on supplementation of molasses based multi-nutrient (MMS) containing chromium for buffaloes and its effect on nutrients utilization, lactation performance and antioxidant status are limited. Hence, the present study

*Corresponding author: Email : ashokdrpatil@gmail.com

was conducted to find out the effect of MMS and chromium picolinate on nutrients utilization, milk yield, microbial protein flow and antioxidant status of lactating Murrah buffaloes.

MATERIALS AND METHODS

Twenty one healthy dairy buffaloes were selected from Cattle and Buffalo Farm in LPM section of ICAR-Indian Veterinary Research Institute, Izatnagar and were housed in a separate shed of having provision of both open and close space. Prior to the experimental feeding, all animals were dewormed with albendazole at 5 mg/kg body weight. Proper health management and sanitation conditions were maintained throughout the experimental period.

Animals were divided into 3 groups of 7 each on the basis of milk yield and body weight (560±10.0 kg) following randomized block design (RBD). All animals were supplied with green forages (5 kg DM/d), wheat straw *ad lib* and concentrate mixture as to meet nutrients requirement of animals (ICAR, 2013). Feeding regimens of experimental buffaloes were similar in all the groups except in the treatment groups where diets were additionally supplemented with 250 g MMS-1 and MMS-2 in T_2 or T_3 groups, respectively. The physical composition of MMS-1 and MMS-2 was same except addition of 2 g chromium picolinate per 100 kg of MMS-2 supplement. Ingredient composition of MMS was molasses (40%), urea (5%), deoiled mahua seed cake (10%),wheat bran (20%), crushed maize (20%), mineral mixture (4%) and salt (1%). Chemical composition of the diet fed to the animals is presented in Table 1. All the diets were isonitrogeneous. The milking was performed twice daily at 5 AM and 4 PM and milk yield (MY) was recorded daily at each milking using an electronic digital balance. The experiment was continued for 210 days, after 90 days of experimental feeding, a digestion trial of 6 days collection period was conducted to determine intake and digestibility of nutrients in different groups. The quantity of feed offered, residue and faeces voided was recorded. Representative samples of feed, residue and faecal samples were collected, preserved and analyzed for their proximate principles (AOAC, 2005) and fibre fractions (Van Soest *et al.,* 1991). During experimental period, daily feed offered and residue leftover was recorded to determine voluntary feed intake at fortnightly intervals. The urine samples (10 ml) were collected after 4-6 h of feeding during the digestibility trial from each animal, the sample of each animal was pooled and kept in a vial containing 20% H_2SO_4 to keep the pH below 3 and analyzed for allantoin (Young and Conway 1942), uric acid and creatinine using commercial kit. Serum was

Table 1. Chemical (% DM basis) composition of feed ingredients

Particulars	Concentrate mix.	Maize green	Wheat straw	MMS
Dry matter (DM)	93.39	21.8	93.08	88.96
Organic matter (OM)	93.09	91.19	93.49	81.59
Crude protein (CP)	17.98	5.96	2.94	23.13
Ether extract (EE)	2.50	1.42	1.35	0.54
Total ash (TA)	6.91	8.81	6.51	18.41
Acid detergent fibre (ADF)	8.38	41.78	51.24	18.86
Neutral detergent fibre (NDF)	38.83	49.43	79.81	35.73
Hemicellulose	30.45	7.65	28.57	25.83
Cellulose	8.35	41.96	51.05	6.06
Calcium (Ca)	0.61	0.43	0.27	0.72
Phosphorus (P)	0.56	0.25	0.08	0.68
Chromium (ppm)	0.87	1.53	0.42	0.93

analysed after thawing for various antioxidant enzymes following standard protocol using commercial diagnostic kit.

Statistical analysis

Statistical analysis: Data pertaining to feed intake, intake and utilization of nutrients were subjected to one way ANOVA. Data pertaining to serum antioxidant profile were subjected to two-way ANOVA Treatment means were separated by Duncan's multiple range test and the differences were considered to be significant at P<0.05. All analysis were performed using statistical package SPSS (20.0).

RESULTS AND DISCUSSION

Results indicated that the voluntary dry matter intake at fortnightly intervals did not vary significantly among three groups. Similar intake of DM and digestibility of nutrients is suggestive of no positive effects of molasses based multinutrient supplements on palatability (Table 2). Earlier finding showed that the sudden introduction of urea into the diet sometimes was associated with palatability problems (Koster *et al.,* 1997). However, in the present experiment MMS-1 and MMS-2 plus were introduced gradually over a period of 25 days that allowed the animals to be adapted smoothly.

Table 2. Intake and digestibility of nutrients and urinary excretion of purine derivatives in different groups

Particulars	Groups			SEM	P-Value
	T_1(control)	T_2	T_3		
Body weight (kg)	572.5±15.9	559.6±15.1	568.2±11.9	6.90	0.859
DMI (kg/d)	12.78±0.01	13.25±0.14	13.00±0.21	0.094	0.111
DOMI (kg/d)	8.49±0.15	8.83±0.17	9.00±0.18	0.106	0.134
CPI (g/d)	1122^{a}±1.21	1193^{c}±5.22	1154^{b}±5.90	8.14	0.001
CPI (g/kg W $^{0.75}$/d)	9.59^{a}±0.01	10.37^{c}±0.05	9.91^{b}±0.05	0.088	0.001
DCPI (g/d)	642.7±11.65	690.7±27.11	686.5±4.38	10.88	0.134
DCPI (g/kg W $^{0.75}$/d)	5.49±0.10	6.00±0.24	5.90±0.04	0.099	0.073
TDN (kg/d)	8.69±0.16	9.05±0.18	9.21±0.19	0.110	0.145
TDN (g/kg W $^{0.75}$/d)	74.26±1.33	78.63±1.55	79.15±1.66	1.01	0.081
Nutrient digestibility (%)					
DM	70.07±1.35	70.33±1.01	72.97±0.41	0.704	0.062
OM	71.83±1.28	72.03±1.02	74.91±0.44	0.645	0.068
CP	57.26±1.08	57.86±2.12	59.52±0.65	0.657	0.353
EE	73.67±3.18	75.38±3.35	75.76±0.54	1.456	0.844
NDF	58.34±2.31	59.13±2.25	61.79±0.83	1.101	0.439
ADF	56.08±1.86	56.63±2.32	58.50±1.02	1.008	0.626
Cellulose	60.53±2.04	60.61±2.44	62.95±1.31	1.102	0.630
HC	64.49±3.31	65.33±2.56	69.22±1.09	1.443	0.388
Urinary excretion (mmol/l)					
Allantoin	3.78±0.625	3.90±0.373	3.75±0.421	0.26	0.972
Uric acid	0.28±0.011	0.25±0.017	0.29±0.012	0.01	0.281
Purine derivatives	4.05±0.63	4.15±0.37	4.03±0.42	0.26	0.982
Creatinine	10.95±0.98	11.85±1.02	11.53±1.07	0.56	0.823
PDC index	42.75±4.29	40.49±1.79	41.02±3.77	1.86	0.890

[abc] Mean values bearing different superscripts varies significantly (P<0.05), (P<0.01)

In agreement to present study, Hosmami *et al.* (1998) observed that there was non-significant increase in intake of DM and TDN due to block feeding in buffaloes while intake of digestible crude protein (DCP) was significantly higher (P>0.01) in UMMB fed group over control group. On the contrary, Tripathi *et al.* (2006) reported that the dry matter intake improved (P<0.05) both in cows (14.13%) and buffaloes (22.76%) as a result of UMMB supplementation, which was reflected in improved (P<0.05) milk yield in cows (31.58%) and buffaloes (35.18%).

Most notable effect of MMS supplementation that we observed in this experiment was, increased intake of N. Intake of CP (g/d and g/kgW$^{0.75}$/d) was higher (P<0.05) in both T_2 and T_3 than control. The apparent digestibility of DM, OM, CP, EE, NDF, ADF and cellulose was not statistically different in 3 groups (Table 2). Similarly, Sahoo *et al.* (2004) reported that the digestibility of DM, OM, total carbohydrate, NDF, ADF, hemicellulose and cellulose in all the dietary groups (fed urea molasses liquid diet) were comparable. Contrary to this finding, Choubey *et al.* (2015) observed that the digestibility of various nutrients was significantly increased in UMMB fed groups, However, such supplements are more effective when the basal ration contained less CP. In the present study, the animals were fed as per the requirement for maintenances and production. Similarly, Sadri *et al.* (2009) reported no change in DMI and DMI as percent in body weight by supplementation (0.8 mg/kgW$^{0.75}$) of dietary Cr to periparturient cows. Report in similar lines is available in lambs (Depew *et al.* 1998).

Urinary excretion of allantoin, uric acid, creatinine and purine derivative index were similar and did not differ significantly among the groups (Table 2). It is thus evident that the MMS-1 and MMS-2 supplementation had no significant effect on microbial protein synthesis. This corresponds well with our data that showed similar dry matter intake, digestible organic matter intake, OM digestibility and TDN intake among the animals of different groups (Table 2). Similar results were also observed by Choubey *et al.* (2015). Urinary excretion of purine derivative is used as a marker of microbial protein synthesis in ruminants. However, excretion of PD in buffaloes is rather less as compared to other species so that PD is not considered to be an

Table 3. Fortnightly mean milk yield (kg/d) of lactating Murrah buffaloes in different groups

Fortnights	Groups			SEM	P-Value
	T_1(control)	T_2	T_3		
1st	7.87±0.57	8.10±0.42	7.86±0.59	0.29	0.94
2nd	7.69±0.62	8.84±0.49	8.05±0.92	0.38	0.47
3rd	7.26±0.56	8.56±0.60	7.38±1.16	0.45	0.44
4th	7.19±0.57	8.28±0.52	8.07±1.24	0.45	0.59
5th	6.60±0.63	7.86±0.61	7.57±1.28	0.48	0.54
6th	6.42±0.63	7.73±0.57	7.17±1.31	0.48	0.55
7th	5.51±0.64	6.99±0.58	6.51±1.37	0.50	0.48
8th	5.15±0.80	6.34±0.46	6.44±1.16	0.47	0.47
9th	4.94±0.57	5.98±0.46	6.07±1.32	0.46	0.56
10th	4.36±0.57	5.44±0.42	6.20±1.09	0.42	0.22
11th	4.31±0.68	5.47±0.45	6.14±0.95	0.41	0.28
12th	4.26±0.50	5.57±0.35	5.30±0.67	0.31	0.18
13th	4.27±0.43	4.34±0.43	4.69±0.36	0.23	0.76
14th	3.60±0.49	4.18±0.47	4.92±0.35	0.27	0.16
Total mean yield	5.67±0.51	6.69±0.43	6.58±0.93	0.36	0.46

effective marker of microbial protein synthesis in buffaloes (Wanapat *et al.,* 2012). While, our objective was to generate data on excretion pattern of PD in buffaloes that would supplement the small pool of data available in this species reported earlier by Dipu *et al.* (2006).

Daily milk production per buffalo was recorded and presented in Table-3. It revealed that overall mean milk production was 5.67, 6.69 and 6.58 kg/day for groups T_1, T_2 and T_3, respectively. The data showed that milk production increased by 1.02 and 0.91 kg/cow/d in groups T_2 and T_3 over control, which was 18 and 16

Table 4. Mean antioxidant status of lactating Murrah buffaloes in different groups

Particulars	Groups	0 Day	90 Day	180 Day	Mean	SEM	T	P	T*P
SOD (u/l)	T1 (control)	33.83	31.64	32.23	32.57[a]	1.02	0.04	0.36	0.55
		±5.10	±4.08	±2.83	±2.21				
	T2	34.95	42.33	40.04	39.11[b]				
		±2.60	±1.87	±1.22	±1.34				
	T3	32.44	37.20	37.94	35.86[ab]				
		±3.21	±2.89	±1.94	±1.60				
	Mean	33.74	37.05	36.74					
		±2.04	±2.02	±1.43					
Catalase (nmol/min/ml)	T1 (control)	44.26	43.33	49.97	45.85[a]	1.59	0.02	0.40	0.85
		±6.06	±5.66	±1.88	±2.74				
	T2	48.19	55.68	56.77	53.55[ab]				
		±8.77	±3.22	±1.47	±3.09				
	T3	55.37	58.26	57.08	56.90[b]				
		±4.53	±4.50	±1.97	±2.09				
	Mean	49.27	52.42	54.61					
		±3.78	±3.00	±1.30					
GPx (nmol/ min/ml)	T1 (control)	12.44	12.35	12.16	12.32[a]	0.39	0.01	0.01	0.12
		±0.86	±0.84	±1.31	±0.55				
	T2	12.67	17.42	16.71	15.60[b]				
		±1.65	0.82	±1.40	±0.91				
	T3	12.23	17.50	17.07	15.60[b]				
		±1.48	±0.82	±1.03	±0.88				
	Mean	12.45[A]	15.76[B]	15.31[B]					
		±0.73	±0.78	±0.90					
Glutathione reductase (nmol/ min/ml)	T1 (control)	140	133	135	136	3.21	0.97	0.93	0.97
		±13.35	±11.98	±10.76	±6.51				
	T2	132	133	139	135				
		±13.35	±6.27	±2.97	±4.71				
	T3	132	134	135	134				
		±6.54	±7.17	±8.69	±4.04				
	Mean	135	133	136					
		±6.24	±4.73	±4.40					

[ab]Mean values bearing different superscripts within a column varies significantly (P<0.05), (P<0.01); [AB]Mean values bearing different superscripts within a row varies significantly (P<0.01)

% per cent more in comparison to control. Similarly, Tanwar (2013) observed that there was an increase of 1.02 l (13.21 percent) milk in UMMB supplemented group. Upreti *et al.* (2010) also observed that average total daily milk production per animal increased by 17.7% (i.e. 1.1 l/day). Our results also corroborated well with the finding of Singh and Singh (2003), Sahoo *et al.* (2009) and Avila (2006). Chromium supplemented group had comparable milk yield with MMS-1 group. Similarly Cr supplementation from either CrPic (Peterson, 2000) or CrMet (Bryan *et al.,* 2004) did not affected milk production in grazing dairy cows where forage was the major source of energy. Contrary to this Deka *et al.* (2015) observed significant increase in milk yield when buffaloes diets were supplemented with 1.0 and 1.5 mg Cr/kg DM.

The results revealed that the chromium supplementation with MMS did not affect the milk yield in mid and late lactation, however, previous researchers have found higher milk yield in chromium supplemented groups in early lactating animals. Most of this difference could be accounted due to the stage of lactation. Most of the lipolytic effect of supplementary chromium is observed during early lactation because of high demand of glucose for the synthesis of milk. Thus, it seems that supplementation of chromium during mid and late lactation may not be beneficial.

Nutritional deficiencies and adverse climatic conditions generally increase the production of free radicals, leading to oxidative stress (Elsayed, 2001; Saleh *et al.,* 2008) which has a negative impact on, live weight gain production and health status of animals. The activities of SOD, catalase and glutathione peroxidase were significantly ($P<0.05$) higher in supplemented groups (T_2 and T_3) than control group (Table 4). The antioxidant status of supplemented group was better in comparison with control group. The animals of group T_2 and T_3 whose diets were supplemented with MMS-1 and MMS-2 had comparable anti-oxidation status indicating that supplementation of chromium may not be beneficial in relation of antioxidant capacity of animal. The better antioxidant status of animals in both the groups is due to only superposing of trace minerals in form of MMS. Similarly, Zhang *et al.* (2014) reported that there was no change in total antioxidant capacity in Cr supplemented group. Similar results were also reported by Parashuramulu *et al.* (2015), where the catalase activity was higher in 80 ppm Zn supplemented calves. Previous studies reported that the supplementation of trace minerals and vitamin (vitamin E and copper) affect the oxidant-antioxidant balance in dairy cows since Cu is a component of SOD and ceruloplasmin (Underwood and Suttle, 1999). Shinde *et al.* (2008) found that supplementation of vitamin E and Se improved the antioxidant status in terms of erythrocyte GSH-Px activity in buffalo calves, as compared to the unsupplemented group. Our results corroborated well with those who reported that micronutrients such as Zn, Cu, Fe and Mn improved the efficiency of antioxidant system (Nagalakshmi *et al.,* 2009).

CONCLUSIONS

From the results it can be concluded that supplementation of molasses based multi-nutrients (250 g/buffalo/day) improved milk yield by 18 (T_2) and 16 (T_3) percent and had better antioxidant status with comparable intake and digestibility of nutrients in lactating Murrah buffaloes.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, ICAR-IVRI and UPCAR for providing all necessary facilities and funds to carry out this work smoothly.

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Received on 18-04-2019 and accepted on 06-06-2019

Indian J. Anim. Nutr. 2019. 36 (2): 130-135
doi: 10.5958/2231-6744.2019.00023.9

Indian Journal of Animal Nutrition

Effect of Feeding Yeast Culture on Productive and Reproductive Performance of Dairy Cows

Ajaz A. Ganie*, Rameez Ali[1], Khurshid A. Dar[2], Henna Hamadani[3], Zahid Bashir[4], T.K. Sarkar[5] and J.D.Parrah[6]

Mountain Livestock Research Institute-Manasbal Safapora-193504, Ganderbal
SKUAST-Kashmir, J&K, India

ABSTRACT

A 105- day feed trial was conducted to evaluate the effect of supplementation of yeast culture on body condition score, body weight changes, dry matter intake, milk production and its composition and reproductive performance in lactating crossbred cows. Twelve multiparous crossbred cows were divided in to two groups (n=6); control group received ration composing of forages and concentrate (60:40). The experimental group received the same diet supplemented with 10 g of yeast (*Saccharomyces Cerevisiae*) per cow per day. The study showed that supplementation with yeast *Saccharomyces cerevisiae* tended (P<0.06) to increase milk production, 4% fat corrected milk (FCM), energy corrected milk (ECM), solid corrected milk (SCM) and milk energy (ME). There was a significant increase of fat (P<0.01) and protein (P<0.05) content also. However, dry matter intake (DMI), body weight and body condition score (BCS) were similar among the groups. Feed efficiency in terms of milk yield/DMI (kg/kg), ECM/DMI (kg/kg) and SCM/DMI (kg/kg) was similar among treatments. Supplementation of yeast culture did not show any effect on duration required for commencement of cyclicity and conception rate. In conclusion, yeast seems to have positive effect on milk production and its fat and protein composition in lactating cows.

Key words: Dairy cows, Milk production, Milk components, Reproductive performance, Yeast

INTRODUCTION

Based on a growing concern over the use of antibiotics and other growth promoters in the animal feed industry, interest in the effects of microbial feed additives on animal performance has increased. Probiotics are a group of functional foods with growing market shares and a large commercial interest (Arvanitoyannis *et al.,* 2005). Probiotics, with regard to animal applications, were defined as live microbial feed supplements beneficially improving the intestinal microbial balance in host animal (Ibrahim *et al.,* 2010). Moreover, they have been approved to provide many benefits to the host animal and animal products. They are used as animal feed to improve the animal health and food safety. Among probiotics, *Saccharomyces cerevisiae* can optimize rumen function by enhancing food components and consequently improve the milk production performance while ensuring digestive efficiency and health of the animal. Yeast (*Saccharomyces cerevisiae*) addition has been reported to increase nutritional value of poor quality forages and high grain diets (Newbold *et al.,* 1996). Beauchemin *et al.* (2003) reported that yeast addition improved the development of rumen lactate-consuming bacteria; prevent accumulation of lactate and rumen pH drop. Yeast is also observed to stimulate cellulolytic bacteria in the rumen, increase fibre digestion and flow of microbial protein from the rumen (Jouany and Morgavi, 2007). Moreover, yeast was reported to improve feed intake and milk yield in dairy cows in several earlier studies (Wohlt *et al.,*1991; Erasmus *et al.,* 1992). The objective of this study was to determine the effect of the use of *Saccharomyces cerevisiae* on milk production, its composition and reproductive performance of dairy cows.

MATERIALS AND METHODS

The study was conducted in SKUAST-K dairy herd, at Mountain Livestock Research Institute (MLRI),

*Correspondence address : Assist. Professor/Jr. Scientist, MLRI Manasbal Safapore-193504 SKUAST-K J&K, Email : ajazganie@skuast kashmir.ac.in Mob. 9622391399; [1] Assist. Professor/Jr. Scientist, ARGO, MLRI Manasbal; [2] Assist. Professor/Jr. Scientist, Agrnomy, MLRI Manasbal; [3]Assist. Professor/Jr. Scientist, LPM, MLRI Manasbal; [4]MVSc Scholar at NDRI Karnal; [5] Senior Scientist, MLRI Manasbal; [6]Scientist Incharge MLRI Manasbal

Manasbal Safapora in Bandipora distirct of J&K. The experiment was carried out between January and April, the period which is characterized by high cold stress in this area. Twelve crossbred cows in their mid-lactation were randomly divided into two groups (yeast and control) of 6 cows each, according to age, body weight, average milk yield, and lactation number. The experiment lasted for 105 days with 15 days of adaptation. Cows of both groups were fed the same ration. However, each cow in the treatment group was additionally supplemented with powdered yeast *Saccharomyces cerevisiae*. Ten grams of the yeast were hand-mixed with a small amount of concentrate and were fed daily to each cow of the experimental group. The cows were housed in separate rows on the farm and had free access to water. Ration was composed of paddy straw, corn silage and concentrate feed. Proportion of forages and concentrate in the ration was 60:40 on dry matter basis. Concentrate was composed of different ingredients (Table 1).

The DMI was recorded daily. The body weight (BW) of each cow was measured fortnightly and body condition score (BCS) was assigned monthly to evaluate the effects of diet on energy status of each cow. Milk production was recorded daily for 105 days and individual milk samples (20 ml) were taken fortnightly and kept at 4°C for analysis of fat, CP, lactose, SNF and total solids.

All reproductive events were recorded, particularly the date of the first observed estrous postpartum and inseminations. Cows were observed regularly for a minimum of 30 min twice daily for signs of estrus. For this purpose they were observed for any obvious swelling of or any mucus discharge from vulva as well as other behavioral symptoms i.e., bellowing, restlessness, mounting other cows or standing still when mounted by other cows. The other important fertility measures included days open, conception rate at first service and number of services required per conception.

Total milk yield was converted to 4% fat corrected milk (FCM), energy corrected milk (ECM), solid corrected milk (SCM), milk energy (ME) yield as per NRC (1989). Milk fat, protein, lactose, solids-not-fat (SNF), and total solids were analyzed using milk analyzer (MilkoScan).

The results of the effects of the diets on the measured parameters were subjected to Analysis of Variance with the GLM procedure of SAS (Statistical Analysis System, 2000) and were compared by *t*-test.

RESULTS AND DISCUSSION

Supplementation with yeast had no significant effect on BCS and body weight over the study period (Table 2), which corroborates with Robinson (1997) and Nocek and Kautzt (2006). Piret *et al.* (2009) also reported a non-significant effect on BCS by feeding yeast culture to early lactating cows. Some researchers found a significant improvement in body condition and body

Table 1. Composition of concentrate mixture

S.No.	Ingridients (% dm basis)	Control (c)	Treatment (t)
1	Maize	25	25
2	Cotton seed cake	13	13
3	Mustard oil cake	23	23
4	Dorb	12	12
5	Wheat bran	15	15
6	Rice bran	5	5
7	Molasses	4	4
8	Mm	2	2
9	Salt	1	1
10	Yeast culture	-	10 grams/head/day
	Total	**100**	**100**

Table 2. Effect of supplementation of diet with yeast on body weight, body condition score and DMI of lactating crossbred cows

Parameter	Control (C)	Treatment (T)
Initial body weight (kg)	252.7±8.12	248.5±9.32
Final body weight (kg)	293.8±8.41	285.0±10.15
Mean body weight (kg)	273.3±5.11	266.8±4.54
Body weight change (kg/fortnight)	5.9±0.11	5.2±0.21
Body condition score	3.21±0.04	3.13±0.02
DMI (kg/day)	8.58±0.15	8.72±0.09
DMI (kg/100Kg BW)	3.14±0.03	3.27±0.01
DMI (g/Kg $W^{0.75}$)	127.54	132.07

weight after adding yeast to the diet of the cow peripartum (Dann *et al.,* 2000; Ayad *et al.,* 2013).

DMI was similar among treatment groups (Table 2), which is in agreement with previous research findings (Rossow *et al.,* 2017; Ramsing *et al.,* 2009) that reported a similar DMI in dairy cattle fed control or yeast product supplemented diet. However, Soder and Holden (1999) reported that supplementation of yeast culture during the first 42 days of lactation increased DMI of lactating Jersey cows.

The results indicated that supplementation with yeast *Saccharomyces cerevisiae* at 10 g/cow/day tended ($P < 0.06$) to increase milk production by about 0.9 kg per cow (Table 3). This is in agreement with other studies reporting increased milk production at the tune of 12% and more (Williams *et al.,*1991; Wohlt *et al.,*1991; Putnam *et al.,*1997; Wohlt *et al.,*1998). Some studies (Robinson, 1997; Dann *et al.,* 2000) reported relatively lower responses ranging from 3 to 9%. Studies on incorporation of probiotic yeast in dairy

Table 3. Effect of supplementation of diet with yeast on milk production and its composition in lactating cross bred cows

Particular	Control (C)	Treatment (T)
Milk yield (kg//animal/day)	9.64^{a}±0.11	10.51^{b}±0.13
4% FCM (kg/day/ animal)	10.39^{a}±0.12	11.99^{b}±0.11
ECM (kg/day/ animal)	9.89^{a}±0.13	11.83^{b}±0.12
SCM (kg/day/ animal)	12.17^{a}±0.11	13.42^{b}±0.13
ME (Mcal.)	9.13±0.20	$10.06^{\pm}$0.18
Milk composition (%)		
Fat (%)	4.52^{a}±0.03	4.94^{b}±0.02
Fat yield (kg/day)	0.44^{a}±0.01	0.52^{b}±0.01
Protein(%)	3.27^{a}±0.02	3.61^{b}±0.03
Protein yield (kg/day)	0.32^{a}±0.01	0.38^{b}±0.01
Lactose (%)	4.1±0.03	4.53±0.02
Lactose yield (kg/day)	0.40±0.01	0.48±0.02
SNF (%)	9.59±0.04	9.03±0.03
SNF yield (kg/day)	0.92±0.01	0.95±0.01
Total solids (%)	14.11±0.18	13.97±0.13
Total solids yield (kg/day)	1.36±0.02	1.47±0.01

Observations with different superscripts (a and b) differ significantly (P<0.05) between the groups

ruminants report great variability in the responses relating to the quantity and quality of milk (Swartz *et al.,* 1994; Soder and Holden, 1999; Wang *et al.,* 2001). A significant increase in milk production, ranging 0.7–2.4 kg per day, was reported by Piva *et al.* (1993) and Robinson and Garrett (1999), whereas no significant effect was reported by other researchers (Erasmus *et al.,* 1992; Dann *et al.,* 2000). Response to probiotics is often very different between studies that could be attributed to the variability related to diets, types and doses of yeast used, and the animals tested (Williams *et al.,* 1991).

Our results show that supplemented cows produced more 4% FCM, ECM and SCM (kg/day/animal) than controls. This relative increase in milk production is not due to overconsumption of dry matter, but could be linked to the complementation of *Saccharomyces cerevisiae* in the food, as reported by Newbold *et al.* (1998). Indeed, all cows in our trial had consumed the similar amount of food (ingested equalized). It is rather associated with better recovery of the nutrients, facilitated by the probiotic through interaction with the microbial flora. Probiotics stabilize rumen pH by competing with bacteria that produce lactate (Beauchemin *et al.,* 2003), providing nutrients and promoting the growth of favourable bacteria by destroying the lactate (Vandehaar *et al.,* 1999). This may results in increase in number of cellulolytic flora resulting in the enhanced degradation of plant fibers, and therefore, the digestibility of the diet (Newbold *et al.* 1998). Furthermore, probiotics enhance the intestinal absorption of nutrients like vitamin B_1 (thiamin), which promotes the colonization of plants by the rumen bacteria, and further improves the digestibility of the ration (Erasmus *et al.,* 1992). The recovery of nitrogen is also permitted by uptake of ammonia by probiotics, which are themselves then digested (Jouany and, Morgavi 2007; Newbold *et al.,* 1996).

As for the chemical composition of milk (Table 3), fat and protein content were enhanced by the addition of yeast. However, SNF, lactose and total solids content were not affected by treatment. The increase in milk production induced by dietary supplementation with *Saccharomyces cerevisiae*, is not always associated with changes in protein and fat content of milk (Vandehaar *et al.,* 1999). Nevertheless, an increase of fat content in the milk of cows fed the probiotic yeast was reported by Piva *et al.* (1993) and Putnam *et al.* (1997). For lactating goat, a significant effect of yeast on the fat content was reported (El - Ghani, 2004; Stella *et al.,* 2007), whereas the protein level was not changed. According to the literature, improvement of fat content of milk of dairy cows supplemented with yeast was associated with a positive effect of the stimulation of cellulolytic bacteria,

Table 4. Effect of supplementation of diet with yeast on feed efficiency and reproductive performance in lactating cross bred cows

Particular	Control (C)	Treatment (T)
Feed Efficiency		
(FCM/DMI, kg/kg)	1.21^{a}±0.01	1.38^{b}±0.01
(MY/DMI, kg/kg)	1.12±0.02	1.21±0.01
SCM/DMI	1.42±0.01	1.54±0.02
ECM/DMI	1.15±0.02	1.36±0.01
Reproductive performance		
Commencement of cyclicity (days open)	84.32±2.21	77.50±3.10
Days open (days)	171.6±5.25	133.5±4.64
AI/Conception	1.66±0.14	2.00±0.11
Conception rate	66.6	50.0

Observations with different superscripts (a and b) differ significantly (P<0.05) between the groups

and a preferred shift of fermentation to acetic acid production, especially for diets rich in concentrate (Piva *et al.,* 1993). An explanation for the higher milk protein content in the experimental group could be the well-known impact of yeast on rumen fermentation and nutrient digestibility which enhances ammonia uptake and improves microbial protein production (Erasmus *et al.,* 1992, Miller *et al.,* 2002), However, a lack of response in milk fat in many studies (Swartz *et al.,* 1994; Soder and Holden, 1999) could be indicative that the stimulation of fibre-digesting ruminal bacteria was insufficient to cause an increase milk fat synthesis in those experiments.

The data regarding efficiency of production are presented in Table 4. The milk yield/DMI (kg/kg), ECM/DMI (kg/kg) and SCM/DMI (kg/kg) were similar among different treatments (P≥0.05). However, the average FCM/DMI (kg/kg) was significantly (P≤0.05) higher in treatment group, indicating that efficiency was improved by supplementing yeast culture in the respective group. Moallem *et al.* (2009) also found that the efficiency of dry matter use to produce 4% fat-corrected milk was 3.7% greater in the yeast supplemented group compared with the control group.

The reproductive parameters recorded in the study are listed in table 4. The duration required for commencement of cyclicity was similar in both the groups. The service period was shorter by 38.1 days in treatment group than control (P>0.05) indicating that lesser time was required by the animals of treatment group for conception. The feeding of yeast may alter fermentation pattern in lactating animals and may be responsible for stimulating the hypothalamus, pituitary gonadal axis resulting in improved reproductive efficiency following feeding of yeast culture. The number of artificial inseminations required per conception was slightly higher in treatment group which might be due to inexperienced inseminator or wrong timing of insemination. The conception rate also was similar in both the groups. Previous studies with direct-fed microbials (Francisco *et al.,* 2002), also showed no effect on reproductive function. Stein *et al.* (2006) reported that there was no treatment, parity, or interaction on days to first postpartum ovulation or on estrous behavior at 45 and 90 d postpartum by feeding *Propionibacteria* to dairy cows. However, a large field study with a greater number of cows and herds is needed to determine the influence of yeast culture supplementation on reproductive performance.

CONCLUSIONS

Incorporation of the yeast culture in the diet of dairy cows improved milk production and composition, but did not influence dry matter intake and feed efficiency.

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Received on 05-04-2019 and accepted on 07-05-2019

Indian J. Anim. Nutr. 2019. 36 (2): 136-145
doi: 10.5958/2231-6744.2019.00024.0

Indian Journal of Animal Nutrition

Effect of Dietary Supplementation of Trace Minerals on Semen Production Performance of Sahiwal Bulls During Winter Season

Manjula Thakur, Asgar Ud Deen, Veena Mani, Mukesh Bhakat[1], Tushar Kumar Mohanty[1] and Goutam Mondal[*]

Animal Nutrition Division, ICAR- National Dairy Research Institute, Karnal-132001, Haryana, India

ABSTRACT

Present study was planned to evaluate the effect of supplemental trace minerals on semen production performance of Sahiwal bulls. Twelve Sahiwal bulls were grouped as T_1, T_2 and T_3 and were supplemented with 0, 1.5 and 2.0 times trace minerals over and above the basal diet in T_1, T_2 and T_3, respectively for a study period of 120 days. All the animals were fed to meet their nutrient requirements as per ICAR (2013). Semen collection was done twice a week in all the groups and samples were evaluated fortnightly for quantitative and qualitative attributes. A digestion trial of seven- days collection period was conducted during d 90-96 of experimental feeding to assess the digestibility of nutrients. Activity of alkaline phosphatase (ALP), lipid peroxidation (LPO), blood antioxidant status and concentrations of (Zn, Cu, Mn, Co, Fe, Ca and P) were estimated in blood and seminal plasma. It was found that additional trace minerals supplementation had no influence on body weight, dry matter intake and digestibility of nutrients among the groups. All seminal parameters except mass activity and post-thaw motility were higher ($P<0.05$) in T_3 group in comparison to T_1 and T_2 groups in fresh as well as frozen semen. Blood antioxidant status was improved in T_3 group. A reduction ($P<0.05$) in LPO activity in fresh and frozen semen in T_3 group was observed. It may be concluded that dietary supplementation of inorganic Zn, Cu, Mn and Co (40 ppm Zn, 10 ppm Cu, 15ppm Mn and 0.11ppm Co) over and above the ICAR (2013) standard in the diets of Sahiwal bull can improve the qualitative and quantitative attributes of semen.

Keywords: Sahiwal,Bull, Trace Mineral, Semen quality

INTRODUCTION

In India, only 25% of the breedable bovine population is under artificial insemination (AI) coverage with a conception rate of about 35%; while rest 75% are covered through natural service either by scrub bulls or with bulls of lower genetic potential (DAHDF, 2018). This is leading to deterioration in the production performance and productivity of most of the important indigenous breeds including Sahiwal. One approach is to provide better nutrition in terms of optimum quantity of trace element in the ration of these animals in addition to energy and protein balance of feed.The current ICAR(2013) guidelines do not make adjustments in mineral requirements for cattle based on growth potential, levels of productivity, physiological status, stress levels, breed, or sex.

Trace minerals are involved in several biological reactions and processes either as a component of metalloenzyme and/or cofactors of various enzymes. Among the trace minerals, supplementation of Zn, Cu, Mn and Co should be considered on account of their deficiency in Indian soil and major influences on male reproduction. Zinc has been reported to influence the process of spermatogenesis, controls sperm motility, stabilizes sperm membrane, preserves the ability of sperm nuclear chromatin to undergo de-condensation and modulates sperm functions (Roy *et al.,* 2013). Copper is involved in spermatozoa motility (Krzyzosiak *et al.,* 2000). Manganese is essential for normal bone growth, onset of puberty, reproductive efficiency of cows and energy metabolism. Mammalian spermatozoal membranes are rich in polyunsaturated fatty acids (PUFAs) and are sensitive to oxygen induced damage mediated by lipid peroxidation and thus are sensitive to reactive oxygen species attack which results in oxidative stress (Sikka, 1996). Superoxide dismutase plays a major role in the protection of spermatozoa from this oxidative damage and Zn, Cu and Mn are component of superoxide dismutase. The need of cobalt for thymine synthesis, which is required for DNA

[1]Livestock Production Management Section; [*]Correspondence author: gmondal1075@gmail.com

synthesis, explains the biological role of cobalt for cell division, growth and reproduction.Rumen synthesis of vitamin $B_{12}$is vital for optimal reproductive fertility in cows (Suttle, 2010) but no data have been reported on the impact of cobalt deficiency on bull fertility.

Apart from the inherent traits, season is one major factor which influences the reproductive performance of these animals and it exerts its effect through macro and micro climatic factors like temperature, humidity, rainfall and photo-period (Mandal *et al.,* 2000).Bhakat *et al.* (2014) observed that the hot-dry or summer season adversely affect the various biophysical characteristics of semen in Murrah buffalo bulls. Winter was the most favorable season for good quality semen production and the rainy season might be considered as the intermediate between the two extremes. Rowe *et al.* (2014) observed improvement in motile sperm, progressive sperm and motile sperm with rapid motility for Angus and Balancer (Gelbvieh × Angus) bulls supplemented with organic as compared with inorganic trace mineral (Zn, Cu, Co, Mn, Se and I). However, no literature is available on the effects of dietary supplementation of trace minerals and season on semen production performance of Sahiwal bulls. Hence, this experiment was conducted to evaluate the effect of supplemental trace minerals on semen production performance of Sahiwal bulls.

MATERIALS AND METHODS

The experimental design and plan of the present study was duly approved by the Institution Animal Ethics Committee of ICAR-National Dairy Research Institute (NDRI), Karnal, Haryana.Twelve mature semen donating Sahiwal bulls (average age 6.0-6.5 years) were selected from Artificial Breeding Research Centre (ABRC) of ICAR-National Dairy Research Institute, Karnal. Three groups (replicates of 4 animals in each group) were formed based on semen volume and concentration. Proper deworming, vaccination and other management practices were followed as per Institute schedule for all the animals.

Animals were fed individually a basal diet, consisting of roughages (berseem and wheat straw) and concentrate (maize-28%, bajra-5%, groundnut cake-10%, soybean meal-15%, mustard cake-13%, wheat bran-15%, rice polish-10%, mineral mixture-2%, common salt-1%) in the ratio of 80:20 (DM basis) to meet their nutrient requirements as per ICAR (2013). Treatments consisted of: 1) T_1 (basal diet with 40 ppm Zn, 10 ppm Cu, 15 ppm Mn and 0.11 ppm Co) served as a control; 2) T_2 (basal diet with 1.5 times higher Zn, Cu, Mn and Co *i.e.* extra 60 ppm Zn, 15 ppm Cu, 22.5 ppm Mn and 0.165 ppm Co); and 3) T_3 (basal diet with 2 times higher Zn, Cu, Mn and Co *i.e.* 80 ppm Zn, 20 ppm Cu, 30 ppm Mn and 0.22 ppm Co). The inorganic mineral supplements ($ZnSO_4$, $CuSO_4$, $MnSO_4$ and $CoSO_4$) were provided through concentrate mixture in the form of premixes. Feed offered and residue left were measured accurately to determine dry matter intake (DMI) of the animals. Average DMI was calculated at fortnightly interval.

A digestion trial of seven day collection period was conducted during days 90-96 of experimental feeding to assess the digestibility of nutrients. Body weight of animals were recorded before and after digestion trial for two consecutive days prior to offering feed and water. Daily record of feed offered, feed consumed, feed refusal and faeces voided by individual animal in control (T_1) and treatment (T_2 and T_3) groups was maintained during this period. Fresh drinking water was provided free of choice. The composition [DM, OM, CP, EE and total ash] of feeds, residues and faeces samples were determined as per AOAC (2005). The fractions of cell wall constituents (NDF and ADF) were also analysed (Van Soest *et al.,* 1991).

During 120 days of experimental period, blood samples were collected from all the animals by jugular vein puncture in heparinized vaccutainer at 0, 60 and 120 day, mixed well by rotating tubes between palms to ensure proper mixing of blood and anticoagulant and brought to the laboratory after placing in ice box. Then the samples were centrifuged at 3000 rpm for 15 minutes to separate the plasma. SOD activity was measured in RBC hemolysate as per Madesh and Balasubramanian (1998) and catalase activity was assayed by the method of Aebi (1984). For the

estimation of seminal alkaline phosphatase (ALP) activity, LPO activity, total antioxidant capacity and minerals (Mn, Cr, Co, Zn and Cu), semen samples were centrifuged at 5000 rpm at 5ºC for 15 min to and stored at -20ºC. Minerals (Zn, Cu, Mn, Co, Ca and Fe and Ca) were estimated in an air-acetylene flame on an atomic absorption spectrophotometer (Hitachi-5000 series) at a wave length of 213.9, 324.8, 279.6, 240.7, 422.7 and 248.3, respectively, and hollow cathode lamp was used as the light source. Phosphorus was measured spectrophotometrically in the ultraviolet region (340nm) using kit supplied by Avecon Healthcare Pvt Ltd., Ambala.

Sexual behavioural features were recorded at the time of semen collection using CCTV camera video recording. Live dummy were used for semen collection of Sahiwal bulls. Different dummy bulls were used on different days to minimize sexual satiation of bull from same dummy, to provide uniform stimulus pressure and randomize dummy effects. The sexual behaviour scoring was done as described by Anzar *et al.* (1993). Sexual behaviour score was divided into two parts; *libido* score and mating ability score. *Libido* was scored on the basis of reaction time (in seconds), sexual aggressiveness and tactile stimulation. Reaction time (RT), dismounting time (DT) and total time taken in mounts (TTTM) was determined using methodology described by Elrabie *et al.* (2008). The score (%) *libido* of each ejaculate, mating ability and sexual behaviour was computed as described by Singh *et al.* (2015).

Semen samples were collected from all the animals twice a week till 120 day of the trial. Ejaculate volume (ml) was recorded to the nearest of 0.1 ml in graduated glass tube. The concentration of sperm (million/ml) in the fresh semen was determined using haemocytometer as per method described by Salisbury *et al.* (1985). Semen pH was noted immediately after collection of the semen using a digital pH meter (Century, India). Mass motility of spermatozoa was graded on a 0-5 scale, based on the appearance of waves and swirls created by sperm movement when visualized under low power microscopic magnification (10X) as per methods described by Salisbury *et al.*(1985). Sperm livability percentage was determined using Eosin-Nigrosin stain. Percent intact acrosome was assessed by staining the semen smears with Giemsa stain. The percentage of HOST positive sperm was observed by incubating semen with a hypo-osmotic solution at 37°C for 60 min and the swelling of the sperm tail was examined under high power microscopic magnification [40X] (Jeyendran *et al.,* 1984).

Each ejaculate was further diluted with pre-warmed Biox-cell extender (IMV technologies-France) to the desired semen concentration per milliliter. The extender was composed of carbohydrates, mineral salts, buffer, antioxidants, glycerine, antibiotics (Gentamycin, Tylosin, Lincomycin and Spectinomycin), phospholipids and ultra-pure water. All extended semen samples were examined for individual motility at 37°C with the aid of a television monitor connected to a microscope. Semen with greater than 50% motile sperm was used for further processing. The diluted semen was cooled from 37ºC to 5°C in a cold cabinet for 2 h, semen was then packed into 0.25 ml polyvinyl French straw (0.25 ml; IMV, L'agile, France) by filling and sealing machine (IMV, Cedex, France). Straws were placed on trays for at least 4 hours at (5°C) for further equilibration. The straws were then plunged into liquid nitrogen (-196°C) and packaged in plastic goblets for storage in the liquid nitrogen container.Thawing of frozen semen was carried out in a water bath at 37ºC for 45 seconds. Parameters for evaluation tests were performed at the time of 24 hour for frozen semen. Procedure for estimation of qualitative parameters of frozen semen (post thaw motility, livability, abnormal sperm, HOST and acrosome integrity) and ALP activity is same as described above for fresh semen.

Data were analyzed using the general linear models (GLM) procedure of SPSS 16.0 computer package. The following model was used:

$$Yij=\mu + di + eij$$

Where, Yij is the observation

μis the general mean

di is the effect of i^{th} treatment

eij is the random error.

Tukey's test was used to observe statistical significance between treatment groups. Significant differences were accepted if P≤0.05.

RESULTS AND DISCUSSION

Chemical composition of the feed ingredients fed to the experimental animals has been presented in Table 1. The values are within normal range and comparable with values reported in literature. DMI was around 9.5 kg/d and 1.7 kg/100kg BW during the experimental period. The average body weights were 553.50±3.57, 538.50±6.59 and 545.06±7.19(kg) in T_1, T_2, and T_3, respectively (Table 2). Digestibility of nutrients (DM, OM, CP, EE, NDF and ADF) was similar (P>0.05) in all the groups (Table 2). Supplementation of trace minerals at higher levels had no effect on DMI, which is in agreement with the report of Shinde *et al.*(2012), who found that DM intake was not affected due to Cu and Zn supplementation in Malpura rams while comparing organic and inorganic sources. Majumdar (2017) and Tarun (2018) also did not find any difference in DMI after trace minerals supplementation. Several earlier studies in ruminants suggested no improvement in nutrient digestibility due to supplementation of trace minerals (Shinde *et al.,* 2012; Majumdar, 2017; Tarun 2018). Garg *et al.* (2008) also reported similar observation except improvement in digestibility of ADF and cellulose when supplemented 20 mg chelated Zn/kg DM in rams suggesting a positive role of Zn in fibre digestion. Contrary to these results, Mondal *et al.* (2008) observed improved (P<0.05) digestibility of DM,CP,CF, ash, EE, AIA, and NFE in all mineral (Cu, Fe, Zn and Mn) supplemented groups. Zn, Cu, Mn and Co act as a component of several metalloenzymes and as a cofactor for numerous other enzymes; thus influencing normal metabolism. However, trace mineral levels in the ration of control group was optimum as per ICAR recommendation, therefore, supplementation above that level did not influence the nutrient intake and digestibility. Change in body weight was not observed as these were mature animals.

Data pertaining to blood and seminal plasma enzymes and mineral profile in different groups (Table 3) showed that supplementation of trace minerals at 2 X than ICAR recommendation resulted in significant improvement in blood and seminal plasma mineral levels except for Co. Concentration of other minerals (Fe, Ca and P) was within biological range depicting no negative effect of higher levels of supplementation on these minerals. Results revealed higher values (P<0.05) of ALP activity (U/L) in blood and seminal plasma in T_3 group against T_1group; however, T_1 and T_2 groups had similar values. Antioxidant status (SOD, catalase and

Table 1. Chemical composition of experimental diet (% DM)

Parameter	Concentrate	Wheat straw	Berseem fodder
DM	89.81	91.06	15.17
OM	90.38	89.34	87.98
CP	19.72	3.15	16.71
EE	4.49	0.78	2.48
TA	9.63	10.67	12.02
NDF	27.04	72.24	46.50
ADF	14.50	57.07	26.92
Zn (ppm)	32.15	19.92	35.24
Cu (ppm)	11.24	4.32	14.72
Mn (ppm)	40.25	42.76	54.15
Co (ppm)	0.95	0.27	0.63
Fe (ppm)	570.15	543.28	824.54
Ca (%)	1.32	0.19	2.1

TAC activity) was improved (P<0.05) in $T_{3;}$ group while, LPO activity was lower (P<0.05) in T_3 group in blood and seminal plasma. Higher concentration of Zn has negative effect on absorption of other minerals, mainly Cu and Fe. However, in the present study, concentration of other minerals (Fe, Ca and P) was within normal biological range depicting no negative effect of higher levels of supplementation on these minerals. Similarly, most of the researchers found no significant effect on serum Cu and Fe levels on supplementing zinc at 20 ppm (Zn methionine or $ZnSO_4$) in lambs (Garg *et al.,* 2008) and 35 ppm ($ZnSO_4$ or Zn propionate) in crossbred calves (Mandal *et al.,*2008). Garg *et al.* (2008) also did not notice any change in serum Mn content in relation to Zn content in the ration (20 ppm either as $ZnSO_4$ or Zn methionine). Garg *et al.* (2008) in lambs, Shinde *et al.* (2012) in Malpura lambs, Aliarabi *et al.* (2015) in lambs, Ramulu *et al.* (2015) in Murrah calves and Majumdar (2017) in Murrah bulls reported significant increase in blood plasma Zn levels after Zn supplementation. While, Cheng *et al.* (2011) in lambs reported significantly higher blood plasma Cu concentration after Cu supplementation. However, Mandal *et al.* (2008) in crossbred calves and Rowe *et al.* (2014) in Angus and Balancer bulls did not report any increase in blood plasma concentration of Zn and Cu, respectively, after supplementing trace minerals above recommended level. Improvement of seminal plasma mineral profile was also reported by Majumdar (2017) and Tarun (2018). ALP is a homodimeric enzyme whose active site contains three metal-binding sites (M_1, M_2 and M_3). The M_1 and M_2 sites are occupied by Zn ions while M_3 site is occupied by one Mg^{2+} ion (Stec *et al.,* 2000). Improved blood plasma ALP activity was also observed in lambs (Aliarabi *et al.,* 2015) in Murrah buffalo calves (Ramulu *et al.,* 2015), and in Murrah heifers (Nagalakshmi *et al.,* 2016) while comparing low doses of organic and higher inorganic Zn supplementation. A highly significant (P<0.01) increase in seminal plasma alkaline phosphatase activity was observed in Zn supplemented groups as compared to the control (Kumar *et al.,* 2006). Better antioxidant response and lowered lipid peroxidation as observed in the present study is in accordance with Nagalakshmi *et al.* (2016), they reported that Zn proteinate lowered lipid peroxidation and increased erythrocyte catalase, GPx and SOD activity in Murrah buffalo heifers. Plasma MDA concentrations were not affected (P>0.05) on day 30, but were decreased (*P*<0.001) on day 60 by Cu supplementation. MDA concentrations were decreased in liver tissues (P<0.05), but were not affected in muscle tissues supplemented with Cu compared with the controls in lambs (Cheng *et al.,* 2011). Aliarabi and Chabbra (2006) reported that

Table 2. Effect of dietary supplementation of trace minerals on intake and digestibility of nutrients of Sahiwal bulls

Parameter	Group		
	T_1	T_2	T_3
DMI (kg/d)	9.70±0.10	9.37±0.11	9.62±0.11
DMI (kg/100 Kg BW)	1.75±0.01	1.74±0.01	1.77±0.01
BW (kg)	553.50±3.57	538.50±6.59	545.06±7.19
Digestibility (%)			
DM	61.06±0.63	60.87±0.77	61.32±1.09
OM	63.10±0.67	62.32±1.41	63.17±1.26
CP	61.96±0.65	61.81±1.09	62.02±0.99
EE	71.22±0.44	72.73±1.00	72.32±0.52
NDF	50.60±0.66	51.34±0.83	51.08±0.58
ADF	40.72±0.61	40.15±1.03	41.70±0.85

40ppm chelated Zn supplementation in crossbred calves increased (P<0.05) SOD activity. Senthil Kumar *et al.* (2008) reported higher (P<0.05) hepatic SOD activity in animals supplemented with 14 mg/kg of $CuSO_4$ in lambs using Cu supplementation at 7 or14 mg/kg DM in the form of sulphate or proteinate.

No difference (P>0.05) in any of the sexual behavioral parameters of Sahiwal bulls receiving graded levels of study trace minerals was observed throughout the trial (Table 4). Animals showed moderate libido based on libido score. Mating ability score was around 80%, while sexual behaviour score was around 70% among the groups. Although there was a trend towards improving the behaviour on addition of these minerals in bulls ration. Zn seems to have regulatory role inthe circulating level of dihydrotestosterone by modulating the 5α-reductase activity (the enzyme which converts testosterone to dihydrotestosterone), which is located in the microsomal and nuclear fraction of the prostate.There is also some evidence that Zn plays role in normal functioning of the hypothalamo-pituitary-gonadal axis. Mn is needed for cholesterol synthesis, which ultimately is required for synthesis of the steroids, estrogen, progesterone and testosterone. But, in our experiment,

Table 3. Blood and seminal plasma biochemicals in different groups

Parameter	Group		
	T_1	T_2	T_3
Blood ALP activity (U/L)	72.71^{b}±0.93	73.48^{b}±1.16	92.68^{a}±4.66
LPO (nmol MDA/mL) in blood	4.42^{a}±0.17	3.96^{ab}±0.19	3.76^{b}±0.19
Blood SOD (U/mg of Hb)	23.52^{b}±0.45	24.56^{ab}±0.61	26.05^{a}±0.69
Plasma catalase activity (µmol of H_2O_2 consumed/min/mg Hb)	1.17^{b}±0.02	1.18^{b}±0.04	1.35^{a}±0.05
Plasma TAC (mM/L)	1.31^{b}±0.02	1.34^{ab}±0.02	1.39^{a}±0.03
ALP (U/100 mL) in fresh semen	171.74^{b}±1.49	172.73^{b}±1.38	179.22^{a}±2.01
ALP (U/100 mL) in frozen semen	330.40^{b}±1.80	330.52^{b}±1.76	336.35^{a}±2.13
LPO (nmol MDA/mL of seminal plasma) in fresh semen	8.49^{a}±0.16	8.21^{ab}±0.17	7.82^{b}±0.19
Blood plasma			
Zn (ppm)	1.06^{b}±0.07	1.07^{b}±0.07	1.37^{a}±0.10
Cu (ppm)	0.92^{b}±0.06	0.98^{b}±0.06	1.17^{a}±0.10
Mn(ppm)	0.16^{b}±0.01	0.19^{b}±0.02	0.23^{a}±0.02
Co (ppm)	0.43±0.04	0.44±0.04	0.47±0.05
Fe (ppm)	2.04±0.12	1.98±0.19	2.02±0.13
Ca (%)	9.88±0.42	9.98±0.40	10.01±0.38
P (%)	4.94±0.36	4.68±0.34	4.66±0.26
Seminal minerals			
Zn (ppm)	29.67^{b}±0.74	30.10^{b}±0.77	33.51^{a}±0.95
Cu (ppm)	2.08^{b}±0.02	2.09^{b}±0.03	2.14^{a}±0.02
Mn(ppm)	1.56^{b}±0.03	1.58^{b}±0.05	1.73^{a}±0.04
Co (ppm)	5.59±0.53	5.67±0.58	5.81±0.41
Fe (ppm)	5.72±0.14	5.77±0.18	5.73±0.19
Ca (%)	13.39±0.70	15.46±0.62	13.73±0.78
P (%)	33.66±0.73	32.42±0.93	35.43±0.84

sexual behaviour was not improved by trace mineral supplementation as in mature animal it is a complex phenomenon controlled by many factors *viz.,* level of testosterone, external environment (high temperature, slippery floor, time of day, noise, stress), prior experience *etc.* masking the effect of nutrition. Similar to our findings, Tarun (2018) didn't observe any change in sexual behaviour of mature Sahiwal bulls supplemented with Mn. Co and Cr at higher levels.

Semen quantitative parameters *viz.*, semen volume, sperm concentration and sperm output per ejaculate (million)were higher ($P<0.05$) in T_3 group (Table 4). Semen qualitative parameters like live sperm count, acrosome integrity and HOST positive sperm count were improved in T_3 group in fresh and frozen semen except pH, mass motility, post thaw motility. Abnormal sperm count in fresh semen was reduced ($P<0.05$) in T_3 group but in frozen semen the effect was non-significant. Semen volume mainly consists of secretion of the testes, epididymis and accessory sex glands, especially prostate gland. Zn has been reported to stimulate growth and development of primary, secondary and accessory sex organs as evidenced by atrophy of these organs in rams, when fed a Zn deficient diet. So, enhanced semen volume by Zn supplementation may be attributed to increased secretory activity of prostatic cells, since 35-40% semen volume is contributed by the prostate gland. Similarly, increased semen volume due to Zn supplementation has been reported by Kumar *et al.* (2006) in crossbred bulls, Shinde *et al.* (2012) in Malpura rams, Sabhapati *et al.* (2016) in crossbred bulls and Majumder (2017) in Murrah bulls. While, Roy (2006) reported no effect of supplementation of trace minerals on semen volume of rams and bulls. The results were in accordance with the earlier findings of Kumar *et al.* (2006) in crossbred bulls, Roy (2006) in Murrah and crossbred bulls, and Majumdar (2017) in Murrah bulls.

Improved livability, acrosome integrity and HOST count of sperm in fresh as well as in frozen semen observed in the present study may be due to the membrane stabilizing action of Zn, anti-oxidant

Table 4. Effect of dietary supplementation of trace minerals on different fresh and frozen semen parameters

Parameter	Group		
	T_1	T_2	T_3
Fresh semen			
Volume (mL)	$3.54^{b}\pm0.10$	$3.60^{b}\pm0.11$	$4.01^{a}\pm0.13$
Concentration (million/mL)	$1170.28^{b}\pm12.79$	$1185.53^{b}\pm14.01$	$1234.11^{a}\pm17.51$
Sperm output per ejaculate (million)	$4123.68^{b}\pm97.99$	$4278.01^{b}\pm149.55$	$4980.28^{a}\pm201.43$
pH	6.62±0.01	6.58±0.02	6.60±0.02
Mass activity (0 to 5 scale)	2.33±0.07	2.36±0.08	2.46±0.08
Live sperm (%)	$76.17^{b}\pm0.91$	$76.53^{b}\pm0.83$	$79.47^{a}\pm0.81$
Abnormal sperm (%)	$9.58^{a}\pm0.36$	$8.75^{ab}\pm0.22$	$8.44^{b}\pm0.24$
Acrosome integrity (%)	$87.17^{b}\pm0.54$	$88.36^{ab}\pm0.51$	$90.03^{a}\pm0.60$
HOST (%)	$56.86^{b}\pm0.59$	$57.92^{ab}\pm0.61$	$59.89^{a}\pm0.65$
Frozen semen			
Post thaw motility (%)	52.75±0.52	53.25±0.58	54.42±0.69
Live sperm (%)	$57.17^{B}\pm0.72$	$57.92^{AB}\pm0.75$	$60.08^{A}\pm0.81$
Abnormal sperm (%)	20.67±0.45	19.92±0.48	19.33±0.61
Acrosome integrity (%)	$62.33^{b}\pm0.43$	$62.75^{b}\pm0.73$	$64.75^{a}\pm0.82$
HOST (%)	$44.08^{b}\pm0.57$	$44.83^{b}\pm0.59$	$46.08^{a}\pm0.77$

properties of supplemented minerals (Zn, Cu and Mn). Zn stabilizes membranes by reacting with sulfhydryl groups of membrane proteins to form stable mercaptides and by inhibition of lipid preoccupation through the inhibition of phospholipases (Bettger and O'Dell, 1981). It reversibly binds to highly unsaturated fatty acid phospholipid side chains such as arachidonic acid. By virtue of which, it prevents leakage of enzymes, proteins and other vital components of sperm, thus extending the functional life of sperm. Seminal plasma contains three main enzymatic antioxidants: superoxide dismutase (SOD), catalase, and glutathione peroxidase/ glutathione reductase (GPx/GRD). There are two forms of superoxide dismutase (SOD), the cytosolic Cu/ZnSOD and the mitochondrial Mn/FeSOD. Further, Zn has been found to stabilize various acrosomal enzymes like acrosin, acid phosphatase and phospholipase, which may account for improved intact acrosome percentage. *In vitro* study with water buffaloes concluded that addition of $CuSO_4$ (0.032 mg/l) to semen extenders led to a significant increase in sperm progressive motility, viability, membrane integrity and total antioxidant capacity during freezing processes and reduce the percentage of sperm with damagedDNA after semen freeze-thawing, which in turn, led to improve semen fertility. However, addition of higher Cu concentrations (0.064 mg/l) was detrimental to spermatozoa (Tabassomi and Alavi-Shoushtari, 2013). Bansal and Bilaspuri (2008) suggested that supplementation of Mn^{2+} to the bull sperm enhances the acrosome reaction by decreasing the oxidative stress. Improvement of these parameters after trace minerals supplementation was also reported by Kumar *et al.* (2006) in crossbred bulls, Roy (2006) in Murrah bulls, Sabhapati *et al.* (2016) in crossbred bulls, Majumdar (2017) in Murrah bulls and Tarun (2018) in Sahiwal bulls. But, Roy (2006) and Majumdar (2017) reported no significant improvement in live sperm percentage in trace mineral supplemented groups.

Reduction of sperm abnormality could be attributed to improved spermatogenesis due to Zn supplementation which may result in sperm maturation, motility and fertilizing capacity. Also Zn is required for sperm maturation during the final stage of spermatogenesis (Rodriguez *et al.,* 1985). Si *et al.* (1990) reported that Zn supplementation improved sperm morphology of bull sperm. Further, antioxidant property of supplemented minerals (Zn, Cu and Mn) might be the reason for reduction in total abnormality of semen.

CONCLUSIONS

Dietary supplementation of Zn, Cu, Mn and Co upto 80 ppm, 20 ppm, 30 ppm and 0.22 ppm did not alter BW, DMI, and digestibility of nutrients (DM, CP, EE, NDF and ADF). Semen production performances *viz.,* volume, sperm concentration, live sperm count, intact acrosome and HOST positive sperm count in fresh and frozen semen were improved in the above mentioned groups. Blood and seminal biochemical parameters and mineral levels (Zn, Cu and Mn) were improved due to supplementation. Based on these results, it may be concluded that Zn, Cu, Mn and Co upto 80 ppm, 20 ppm, 30 ppm and 0.22 ppm supplementation will be beneficial in improving the quality of bull semen.

ACKNOWLEDGEMENTS

The authors are thankful to Director ICAR-National Dairy Research Institute, Karnal for providing necessary funding and facilities for conducting the experiment.

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Received on 26-04-2019 and accepted on 12-06-2019

Indian J. Anim. Nutr. 2019. 36 (2): 146-152
doi: 10.5958/2231-6744.2019.00025.2

Indian Journal of Animal Nutrition

Effect of Pudina (*Mentha piperita)* Supplementation on Nutrient Utilization and Blood Biochemical Parameters of Sheep

A. Ishfaq*[1], A.R. Bhat, A.M. Ganai, Y.A. Beigh and G.G. Sheikh
Division of Animal Nutrition, Faculty of Veterinary Sciences & Animal Husbandry,
SKUAST- Kashmir Shuhama-190006

ABSTRACT

The present study was undertaken to evaluate the effects of Pudina *(Mentha piperita*),a herbal feed additive, on the nutrient balance and blood biochemicals in sheep.Ten male adult Bakerwal sheep were divided in to control (T_0) and treatment (T_1) groups. The complete ration for T_1 was fortified with herb *Mentha piperita* @3%. Intake of DM, OM and body weight was observed. Digestibility coefficients of DM, OM, CP and EE showed significant (P<0.05) differences where as non-significant (P<0.05) differences were observed in digestibility coefficients of NFE, NDF, ADF and HC. Significant (P<0.05) increase in DCP and TDN were recorded in T_1 group as compared to T_0 group. Nitrogen, calcium and phosphorus balance were comparable between two groups and were positive in both the groups. Among haemato-biochemical parameters blood glucose, Hb, PCV and total serum proteins, differed non-significantly (P≤0.05) between the groups, both before and after experimental feeding except the BUN, which was found significantly (P≤0.05) higher in herb supplemented group. It was concluded that Pudina could be used as feed additive @3% of diet for enhancing digestibility in sheep without any negative effect on body weight, nitrogen balance or blood biochemical parameters.

Key words: Bakerwal sheep, Haemato-biochemical, *Mentha piperita*, Nutrient utilization

INTRODUCTION

Antibiotics use as growth promoters has revolutionized the livestock and poultry sector in terms of growth and production in developed nations. But at the same time, it has threatened the health sector with the problem of antibiotic resistance and development of super bugs. As a consequence, the use of antibiotics as a livestock feed additive has been banned in many countries (Russell and Houlihan, 2003).Nowadays non-antibiotic growth promoters are receiving due attention and researchers are focusing on natural herbal additives as alternative to antibiotic growth promoters (Wanapat *et al.,* 2008). India being rich in natural medicine and feed additives, is receiving due attention of researchers for providing alternatives to antibiotics and other hazardous chemicals. Phytobiotics or phytogenic feed additives are the natural bioactive compounds of plant origin incorporated into animal feed to enhance livestock productivity through the improvement of digestibility, nutrient absorption and elimination of resident pathogens in the animal gut (Athanasiadou *et al.,* 2007) with the aim to improve production performance and the quality of food derived from animals (Windisch *et al.,* 2008).The application of herbal feed additives in livestock ration has tremendous potential for improvement in nutrient utilization as well as growth and production (Balunas and Kinghorn, 2005).

Mentha piperita, locally known as Pudina, belongs to family*Lamiaceae*. It is used as digestive, carminative, chloretic, antispasmodic, diuretic, antiemetic, mild sedative, diaphoretic, antiseptic, antiviral, and is widely used in many mixtures for treatment of indigestion, colic, cough and cold remedies (Robers and Tyler, 1999). Peppermint oil, as feed additive has been used as a rumen fermentation modifier and has been reported to decrease methane production with simultaneous improvement in digestibility of protein and ether extract (Agarwal *et al.* 2009). Bhat *et al.,* (2017a) reported that incorporation of Mentha piperita at 3% in the substrate enhanced digestibility and rumen fermentation *in vitro*. Based upon the encouraging results of *in vitro* experiment, the present study was

*Corresponding author: Ahmad Ishfaq PhD Scholar, Division of Animal Nutrition, Faculty of Veterinary Sciences & Animal Husbandry, SKUAST- Kashmir Shuhama-190006; email: shfa758@gmail.com

Table-1: Chemical composition of complete feed, feed additives and feed ingredients (% DM basis)

Feed	DM	OM	CP	EE	CF	NFE	TA	NDF	ADF	HC	Ca	P
Complete Feed	91.7	90.9	13.8	6.10	32.4	38.5	9.15	63.6	42.3	21.3	1.42	0.73
Ingredients												
Maize	91.5	94.6	8.60	3.10	3.60	79.3	5.40	14.4	5.45	8.91	0.15	0.22
Wheat bran	90.5	91.3	14.5	4.21	11.3	61.4	8.70	39.7	17.3	22.3	0.14	0.97
Rice bran	89.6	90.6	9.90	2.30	23.5	54.9	9.40	61.5	35.6	25.9	0.59	1.22
Mustard cake	91.5	91.3	34.6	7.60	14.4	34.7	8.70	31.4	16.5	14.9	0.60	1.05
Mineral mixture	98.1	-	-	-	-	-	100	-	-	-	26.22	13.65
Common salt	96. 5	-	-	-	-	-	100	-	-	-	-	-
Oats straw	92.1	90.3	3.40	1.03	51.2	34.6	9.70	69.5	48.6	20.9	0.20	0.07
Mentha piperita	93.4	90.2	15.9	3.21	12.6	58.5	9.76	43.6	22.6	20.9	1.20	0.56

undertaken to evaluate the *in vivo* effect of *Mentha piperita* L. (Pudina) as feed additive in complete ration of sheep.

MATERIALS AND METHODS

The study was carried out at Mountain Research Centre for Sheep and Goat, Shuhama, SKUAST-Kashmir, India. Pudina leaves (*Mentha piperita)* were collected from surroundings as it grows in wild. Leaves were collected before flowering stage and dried and ground to uniform size prior to mixing with feed. Ten male adult Bakerwal sheep (about 17-20 months of age and 28±2 kg body weights) were randomly allotted on body weight basis into two equal groups (n=5) namely, control (T_0) and treatment (T_1) group. Complete ration with concentrate mixture and oats straw in 40:60 ratios was provided to all the animals as per ICAR (2013). The complete ration for treatment group (T_1) was supplemented with 3% *Mentha piperita*.The concentrate mixture was formulated containing maize, rice bran, wheat bran mustard cake, mineral mixture and salt in the ratio of 25, 17, 25, 30, 02 and 01 per cent, respectively.The animals were fed twice daily with free access to water. Feed offered and residues were recorded daily from each ram before the addition of fresh feed next day during the experimental period of 30 days. Body weight was recorded at fortnightly interval. To assess the digestibility of nutrients and balance of nitrogen and minerals (calcium and phosphorus), a metabolism trial of 7 days duration was conducted. The chemical composition of complete ration, ingredients and Pudina used in experiment was analysed as per procedures of AOAC (2000), Van soest *et al.* (1991) and Talapatra *et al.* (1948).

Blood samples were drawn from the jugular vein of the experimental animals at the start and end of the experiment. Haemoglobin was estimated by Sahli's haemoglobinometer (Edwin and Howard, 1923), PCV by Microhematocrit method (Brian *et al.,* 2000), total protein by Biuret method (Murtuza, 1998) and blood glucose by O-toludine method (Marks, 1959). BUN was estimated as per method described by Skeggs (1957).

Data were subjected to analysis of variance

(ANOVA) for completely randomized design, using the Statistical Package for the Social Sciences, Base 14.0 (SPSS Software products, Marketing Department, SPSS Inc. Chicago, USA). The Comparison among means was done by the least significant difference (LSD) test of Duncan.

RESULTS AND DISCUSSION

The complete ration formulated contained 91.65% DM, 90.85% OM, 13.80% CP, 6.10% EE, 38.53% NFE, 9.15% TA, 63.56% NDF, 42.25% ADF, 21.31% hemicelluloses (HC), 1.42% calcium (Ca) and 0.73% phosphorus (P). Pudina composed chemically of 90.24% OM, 15.89% CP, 3.21% EE, 58.54% NFE, 9.76% TA, 1.2% Ca and 0.56% P, respectively. Mainasara *et al.,* (2018) reported that dried peppermint contained 56.31% carbohydrates, 7.69% protein, 5% lipid, and 22% ash.The analysis of *Mentha piperita* revealed that it contained 43.56% NDF, 22.63% ADF and 20.93% hemicellulose. Wanapat *et al.,* (2013) reported that Pudina has 92.4% DM, 87.5% OM, 1.20% CP, 3.30% NDF, 17.3% ADF, 1.20% EE and 7.2 % essential oil. Hosoda *et al.* (2005) reported similar results in peppermint powder except that their samples contained lower amount of CP. The variation in composition may

Table 2. Effect of Pudina (*Mentha piperita*) on feed intake, body weight, digestibility and nutrient utilization in sheep

Attributes	Control (T_0)	Treatment (T_1)
Feed intake (g/d)		
DMI	887.60^{a}±4.28	942.40^{c}±4.11
OMI	824.20^{a}±3.05	889.00^{b}±3.29
Initial body weight (kg)	28.05^{a}±2.10	28.07^{a}±2.16
Final body weight (kg)	29.61^{a}±2.18	30.03^{b}±2.21
Total gain (kg)	1.56	1.96
Digestibility (%)		
DM	57.82^{a}±1.70	66.39^{b}±0.64
OM	57.36^{a}±1.50	64.38^{b}±1.33
CP	60.10^{a}±1.06	66.07^{b}±1.60
EE	55.92^{b}±1.29	66.11^{b}±0.97
NFE	66.27±1.06	68.35±0.72
NDF	48.80±0.98	50.43±0.56
ADF	39.83±0.83	41.45±1.46
HC	58.76±0.71	59.29±1.34
Nutritive value (%)		
DCP	8.30^{a}±0.15	9.12^{b}±0.22
TDN	65.18^{a}±0.58	69.13^{b}±0.73
NR	6.86±0.16	6.6±0.18
DE (kcal/g)	2.45^{a}±0.02	2.60^{b}±0.03
ME (kcal/g)	2.02^{a}±0.16	2.14^{b}±0.02
Nutrient intake (g/d)		
DDM	524.80^{a}±1.71	561.60^{b}±3.98
DOM	508.40^{a}±1.94	542.80^{b}±3.72
DCP	73.63^{a}±1.53	85.92^{b}±2.01
TDN	578.59^{a}±5.76	651.42^{b}±7.26

Means superscripted with different letters in a row differ significantly (P<0.05)

be due to difference in Pudina species according to different geographical areas. The source of variation may also be Pudina *per se,* in the present experiment, wild grown varieties were used, unlike cultivated Pudina no fertilizers or nutrients were applied. Besides leaves were collected at growing stage which may be the reason for variation too.Lemon grass and Pudina have been reported as feed additives to improve production performance of beef and dairy cattle (Hosoda *et al.,* 2005; Yang *et al.,* 2007) and to enhance rumen fermentation efficiency (Kongmun *et al.,* 2010). The average values of dry matter and organic matter intake in terms of g/d were significantly (P<0.05) higher in treatment (T_1) than control group (T_0) as depicted in table 2. Atta-Elmnan *et al.* (2013) similarly reported increase in DM intake from 622 to 955 g/day at 5% fenugreek seed inclusion level. Ganai *et al.* (2011) also reported higher intake of feed containing *Eclipta alba* as feed additives in complete ration of goats. Bhat *et al,* (2017b) reported similar results in sheep supplemented with *Artemisia absinthium*. The increase in feed intake may be due the presence of active compounds such as essential oils that stimulate appetite and improve the digestion by suppressive action on gastrointestinal disorders (Asadi *et al.,* (2017). Ismail (2000) ascribed increase in feed intake to saponin content in herbs in growing Barki lambs. In contrast, Wanpat *et al.,* (2013) reported no effect on DM intake on herb supplementation. Average digestibility coefficients of DM, OM, CP and EE were found to be significantly

Table 3. Effect of Pudina *(Mentha piperita)* on balance of nutrients in sheep

Parameters	Control (T_0)	Treatment (T_1)
N intake (g/d)	20.37^a ±0.68	23.40^b ±0.34
Excretion		
Faeces (g/d)	7.19±0.04	7.09±0.06
Urine (g/d)	5.36±0.34	6.03±0.20
Balance		
(g/d)	7.81^a ±0.37	10.27^b ±0.20
% of intake	38.30^a ±0.63	43.88^b ±0.60
% of absorbed	59.39^a ±0.97	63.00^b ±0.82
Ca intake (g/d)	11.15^a ±0.18	12.56^b ±0.12
Excretion		
through faeces (g/d)	4.47^a ±0.12	5.25^b ±0.10
through urine (g/d)	2.29±0.03	2.37±0.07
Balance		
g/d	4.38^a ±0.16	4.94^b ±0.24
% of intake	39.35^a ±1.15	39.32^a ±1.64
% of absorbed	65.61^a ±0.88	67.49^b ±1.58
P intake (g/d)	7.27^a ±0.08	7.62^b ±0.09
Excretion		
through faeces (g/d)	2.26±0.03	2.44±0.05
through urine (g/d)	2.11±0.03	1.92±0.05
Balance		
g/d	2.90^a ±0.02	3.25^b ±0.03
% of intake	39.76^a ±0.45	42.70^b ±0.70
% of absorbed	57.80^a ±0.27	62.80^b ±0.75

Means superscripted with different letters in a row differ significantly (P<0.05)

($P<0.05$) higher in T_1 as compared to T_0.Atta-Elmnan *et al.* (2013) and Abo El Nor *et al.,* (2007) reported increase in nutrient digestibility in Nubian goats and lactating buffaloes on fenugreek supplementation, respectively. The higher values for digestibility in T_1 may be due to improvement in liver function (Zong *et al.,* 2011), strong anti-oxidant (Tsai *et al.,* 2013) and anti-bacterial activity (Kapp, 2015). Essential oils (EOs) appear to suppress harmful microorganisms, stimulate beneficial microbes such as Lactobacillus spp., regulate the activity of enzymes and protect gut villi. They beneficially affect the ecosystem of gastrointestinal microflora by controlling potential pathogens, alleviating the oxidative stress caused by them and stabilizing gut microbiota (Simitzis, 2017). Moreover, digestive secretions (saliva, bile, mucus, *etc.*) and enzyme (trypsin, amylase, lipase, *etc.*) activity are enhanced partially through the irritation of the epithelial tissues, resulting in an increased gastric retention time of the ingested feed and a better nutrient absorption (Patel and Srinivasan, 2004). The percent digestibility of CF,NFE, NDF, ADF and HCwas found to be statistically non-significant ($P<0.05$) between experimental groups.The present results of no change of fibre digestibility were consistent with the previous findings of Hosoda *et al.* (2006), Atta-Elmnan *et al.* (2013), Pattanaik *et al.* (2009) and Ganai *et al.* (2011).However, Ando *et al.* (2003) reported that supplementation with peppermint could increase nutrient digestibility which contradicts with the present findings.

Significant ($P<0.05$) positive effect was seen in the treatment group for nitrogen, calcium and phosphorus balance. The results are in agreement with the findings of Bhat *et al,* (2017b), Atta Elmnan *et al.* (2013) and Ganai *et al.* (2011) who reported increase in nitrogen, calcium and phosphorous retention in ruminants when supplemented with herbs. Fernandez *et al.* (1997) used a commercial blend of EO compounds to manipulate rumen fermentation, inhibiting the breakdown of protein, thus potentially increasing the dietary protein available to the ruminant.The phytoactives of Pudina increases the digestibility of dry matter, which in turn may be reflected in more retention of nitrogen and minerals in treatment group. Any beneficial effects of EO on protein metabolism may have to be balanced against possible detrimental effects on fiber breakdown (McIntosh *et al.,* 2003).The fact that constituents of peppermint oil appear in the urine indicates that it must eventually cross the intestinal epithelium and would therefore be capable of exerting actions on secretory mechanisms as well as influencing absorption when it is present at the luminal surface (Beesley *et al.,* 1996). Braun *et al.,* (2019) reported that essential oils may not only influence ruminal fermentation but also modulate the absorption of cations like Na^+, Ca^{2+} and NH_4^+ across ruminal epithelia of cattle and sheep through direct interaction with epithelial transport proteins, such as those of the transient receptor potential family. Intriguingly, EO have been shown to enhance the transport of Ca^{2+} and other cations across numerous preparations (Nilius and Szallasi, 2014).

Significant ($P<0.05$) differences were observed between control (T_0) and treatment group (T_1) in terms of DCP and TDN content of the diets with non-

Table 4. Effect of Pudina (*Mentha piperita*) on blood biochemical parameters

Attributes	Control (T_0)		Treatment (T_1)	
	0 day	30th day	0 day	30th day
Hb (g/dl)	10.52±0.07	10.90±0.06	10.66±0.09	11.11±0.10
PCV (%)	28.12±0.23	29.08±0.30	28.18±0.42	29.00±0.27
Blood glucose (mg/dl)	56.77±1.00	58.57±1.05	56.33±0.67	57.29±±0.66
Total proteins (g/dl)	6.24±0.20	7.09±0.07	6.28±0.18	7.16±0.10
BUN (mg/dl)	19.68±0.62	20.84±0.63	19.71^a±0.71	22.94^b±0.25

Means superscripted with different letters in a row differ significantly ($P<0.05$)

significant effect on NR. The improvement in DCP content on dietary supplementation of herb might be due to better microbial protein synthesis in T_1. There was higher (P<0.05) DDMI, DOMI, DCPI and TDNI in treatment (T_1) group than control (Table 2), as also reported by Kraszewski *et al.* (2002) and Gupta *et al.* (2005).

Blood biochemical parameters were within the normal ranges mentioned by Constable *et al,* (2017) (Table 4). The mean values of Hb, PCV, blood glucose and total serum protein concentration did not differ significantly (P>0.05) in animals among different groups. Values of BUN were significantly (P<0.05) higher in treatment group (T_1) as compared to control (T_0). It may be due to increase in ammonia fermenting bacteria, which in turn lead to more urea production. Khattab *et al.* (2011) reported similar results on feeding of phytogenic feed additives in small ruminants.

CONCLUSION

The current study concludes that Pudina (*Mentha piperita)* can be used as feed additive @3% of diet for enhancing digestibility in sheep without any negative effect on body weight, nitrogen balance or blood biochemical parameters.

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Received on 15-04-2019 and accepted on 02-06-2019

Indian J. Anim. Nutr. 2019. 36 (2): 153-157
doi: 10.5958/2231-6744.2019.00026.4

Indian Journal of Animal Nutrition

Evaluation of Banana Plant Waste and its Silage-based Diet on Performance of Osmanabadi Goats

S.N. Anjaneya*, B. Ramachandra, T. Thirumalesh and P.K. Anup Kumar
Department of Animal Nutrition, Veterinary College, KVAFSU, Bidar-585401, Karnataka, India

ABSTRACT

The fresh banana plant waste (FBPW) and its silage (FBPWS) based diets were evaluated in Osmanabadi goats for six weeks. Thirty goats (n=30) were divided into six groups of five each and allotted to one of the following diets: T_1 (FBPW plus concentrate feed mixture; CFM), T_2 (FBPWS alone), T_3 (FBPWS plus CFM), T_4 (FBPWS plus soybean meal), T_5 (FBPWS plus maize mixed with slow releasing nitrogen product) and T_6 (FBPWS plus wheat bran). Restricted feeding of red gram straw (RGS) was carried out in all groups. The crude protein content of the diets varied from 6.18 to 19.80%.The total dry matter (TDM) and crude protein (CP) intake for T_1, T_2, T_3, T_4, T_5 and T_6 groups varied from 384.75 to 554.07 and 23.79 to 95.57 g/d, respectively. Furthermore, animals in all the groups were on positive nitrogen balance with similar biochemical parameters. It was concluded that FBPW with CFM and FBPWS with SBM based diets were superior over remaining silage based diet in terms of achieving higher body weight gain.

Key words: Banana plant waste, Red gram straw, Silage, Serum biochemical parameters

INTRODUCTION

Banana (*Musa paradisiaca)* is the second largest fruit produced after citrus, contributing 16% of the world's total fruit production. India is the largest producer of banana contributing 27% of world's banana production (Mohapatra *et al.,* 2010). After harvesting the fruits, plants are thrown as wastes, which can be better utilized if the moisture content is reduced and supplemented with little concentrate feeds (Gupta *et al.,* 2001, Marie-Magdeleine *et al.,* 2010). However, in order to increase its shelf life for continuous and constant supply, silage making is preferred. This can be ensiled by reducing moisture by addition of any dry roughages and cereal grain powder as a source of energy to enhance fermentation process to obtain good quality silage. However, the information on making and utilization of FBPW based silage as ruminant feed is scarce. Hence, this experiment was conducted to study the effect of feeding different types of FBPW based silage on performance and serum biochemical parameters of goats.

MATERIALS AND METHODS

Aerial part of two year old banana plants (*Musa paradisiaca*) of G-9 variety were harvested after removing the fruits and were chopped manually to a length of 1-2 inches, dried under sun light till the moisture was reduced to 73%. Then chopped banana plant waste (85%) was mixed with sugarcane bagasse (13%) and sorghum grain (2%) powder to reduce the moisture content to 63.35%. The same was trampled/ filled layer by layer in silo pit up to the brim to have compaction density of approximately 320 kg wet matter/m^3(less due to sponginess nature of plant). The pit was covered with plastic sheet (tarpaulin sheet) and made air-tight by covering with mud and dung slurry.After 6 months (due to inclement weather), silo pit was opened and silage was studied for their physical and chemical characteristics.

Dry matter of silage was estimated by toluene distillation method (Dewar and McDonald, 1961). The samples of FBPW, RGS, diets and fecal samples were dried in a hot air oven at 60°C until constant weight and were subjected for proximate (AOAC, 2005) and fibre fractions (Goering and Van Soest, 1970) analysis.

A growth trial was conducted using thirty female Osmanabadi goats (8-11 months age; 16 kg BW), divided into six groups of five goats each in an experiment based on completely randomized design (CRD) and the experiment lasted for six weeks Treatment 1 (T_1) comprised of feeding of fresh banana

*Corresponding author:anju0523@rediffmail.com

plant waste (FBPW) with 247 g of concentrate mixture. Treatment 2 (T_2) acted as negative control that comprised of banana plant waste silage alone (FBPWS). Treatment 3 (T_3) acted as positive control comprised of FBPWS with 247 g CFM. Treatment 4 (T_4) comprised FBPWS with 157 g soybean meal. Treatment 5 (T_5) comprised of FBPWS with 245 g ground maize grain mixed with 10 g slow releasing nitrogenous product (SRNP). Treatment 6 (T_6) comprised of FBPWS with 239 g wheat bran or single ingredient concentrates was supplied to balance energy and protein. The FBPW and its silages were fed *ad lib* while red gram straw (*Cajanus cajan)* was fed to all groups in order to meet DM requirement. All the treatments were equally supplemented with mineral mixture.

Goats were individually dewormed before commencing the feeding trial and fed similar rations for 45 days. The FBPS/FBPWS and CFM were fed separately in small proportions. The daily allowance of CFM was fed twice at 07.30 and 17.00 h. Goats were weighed every week using an electronic weighing balance before access to feed and water. A metabolism trial of 5- days collection period was conducted at the end of trial, during which daily intake of feeds, output of faeces and urine were recorded. Faeces and urine were collected manually by total collection method, one tenth of daily faeces voided by individual goats were used for DM determination (60°C) and stored for further chemical analysis. Samples of faeces and urine were preserved using 10%(v/v) H_2SO_4 for N estimation (AOAC,2005). Blood samples were drawn before morning feeding at the start and end of experiment from jugular vein of all experimental goats in non-heparinized tube, serum was separated and frozen at -20°C. Serum was analyzed for total protein, albumiun, globulin, albumin:globulin ratio as described by Gornall *et al.* (1949) and serum urea nitrogen by Fawcett and Scott (1960). Experimental data on DMI, nutrient intake, body weight gain, digestibility, nitrogen balance and blood parameters were subjected to analysis of variance using the General Linear Model procedures of Statistical Analytical System (SAS Institute Inc., 2012, Version, 9.3.1). All the percent values have been converted by arc sine transformation and standard error of mean (SEM) values presented are of the arc sine transformed data.

RESULTS AND DISCUSSION

The chemical composition of roughages and experimental diets has been presented in Table 1. All the diets were comparable with respect to CP except T_2 and T_4 because the T_2 comprised only roughage component and T_4 contained SBM in addition to roughage.

The data on nutrient intake and digestibility have been illustrated in Table 2.The DMI from FBPW was significantly lower in T_3 group, whereas, DMI in groups fed silage alone was significantly higher ($P<0.01$) when compared to other groups. The higher ($P<0.01$) DMI was achieved when FBPWS was used as a sole source of roughage than the FBPW or FBPWS were supplemented with either CFM or any single ingredient

Table 1. Chemical composition (% on DMB) of diets used in experiment

Particular	FBPW	T_1	T_2	T_3	T_4	T_5	T_6
Organic Matter	85.22	93.21	89.67	92.98	89.77	93.08	91.26
Crude Protein	8.84	11.54	6.18	12.10	19.50	10.24	11.15
Ether extract	1.27	1.85	1.35	1.91	1.35	2.17	1.97
Total ash	14.78	6.79	10.33	7.02	10.22	6.92	8.74
Neutral detergent fibre	67.31	49.22	70.27	44.70	55.17	41.97	56.89
Acid detergent fibre	43.90	27.84	48.17	25.79	34.32	25.41	28.64
Lignin (sa)	9.39	6.87	10.64	5.93	7.90	5.98	6.92

T_1;FBPW+CFM+ RGS; T_2;FBPWS+RGS;T_3:FBPWS+CFM+RGS; T_4:FBPWS+SBM+RGS;T_5;FBPWS+Maize+SRNP+RGS; T_6FBPWS+Wheat bran+RGS

concentrates. However, to improve DMI of FBPW and its silage, RGS was incorporated into diets of all the groups along with concentrate supplements except in T_2 group. Goats of all the groups consumed more DM from RGS than FBPW or FBPWS. The purpose of incorporation of RGS to improve intake of FBPW or FBPWS was defeated as animal had shown more inclination towards RGS intake than high moisture containing FBPW and FBPWS. The same trend was also observed in the intake of OMI. The CPI was significantly higher ($P<0.01$) in T_4 group due to supplementation of SBM followed by T_1, T_5, T_3 and T_6. The NDFI and ADFI among the groups were related to the roughage intake in the respective groups. Similar observations were noticed by Gupta *et al*. (2001) for banana plant waste and Khattab *et al*. (2000) for banana plant silage.

The digestibility of DM, OM and CP was significantly ($P<0.01$) lower in T_2 group than the other groups which had almost similar digestibility. However, NDF and ADF digestibility was lower in T_5 group which was due to addition of maize; NDF and ADF digestibility were comparable in T_2 group to other group even though T_2 was not supplemented with any

Table 2. Intake(g/d), nutrient digestibility (%), body weight gain, nutrient density (%) and nitrogen balance (g/d) in experimental goats

Phase	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Nutrient intake (g/d)							
FBPW/S intake	67.68^{ab}	188.94^{c}	56.82^{a}	95.48^{ab}	99.94^{b}	66.50^{ab}	4.22
RGS intake	239.32	195.80	143.59	239.32	143.59	174.05	-
Concentrate	247.07^{c}	-	247.07^{c}	156.66^{a}	244.73^{c}	239.07^{b}	0.49
Total DMI	554.07^{d}	384.75^{a}	447.49^{b}	491.46^{c}	488.26^{bc}	479.62^{bc}	4.44
OM intake	516.41^{d}	345.24^{a}	416.18^{b}	441.45^{bc}	454.63^{c}	437.78^{bc}	3.76
CP intake	63.73^{c}	23.79^{a}	54.24^{b}	95.57^{d}	62.32^{c}	53.42^{b}	0.28
NDF intake	273.77^{b}	270.36^{b}	199.60^{a}	271.46^{b}	204.60^{a}	273.07^{b}	3.02
ADF intake	155.00^{cd}	185.33^{e}	115.04^{a}	168.90^{de}	123.83^{ab}	137.60^{bc}	2.30
Digestibility of nutrients(%)							
DM	73.46^{b}	54.97^{a}	73.07^{b}	68.65^{b}	65.77^{ab}	64.38^{ab}	0.77
OM	75.92^{b}	59.03^{a}	76.49^{b}	71.68^{b}	68.89^{ab}	67.74^{ab}	0.71
CP	56.34^{a}	48.30^{a}	58.23^{ab}	69.87^{b}	50.39^{a}	53.71^{a}	0.82
NDF	59.99^{b}	54.38^{b}	54.22^{b}	57.46^{b}	35.18^{a}	51.07^{ab}	1.10
ADF	54.31^{c}	51.66^{bc}	42.71^{abc}	49.95^{bc}	31.87^{a}	33.92^{ab}	1.10
BW gain (g/d)	66.67^{b}	16.05^{a}	38.72^{ab}	45.62^{ab}	33.29^{ab}	23.90^{a}	3.51
Nutrient density							
DCP (%)	6.52^{b}	3.08^{a}	7.77^{b}	15.13^{c}	6.95^{b}	6.25^{b}	0.16
TDN (%)	72.71^{cd}	54.87^{a}	75.21^{d}	65.91^{bcd}	58.79^{ab}	64.21^{abc}	0.66
ME, (MJ/kg DM)	10.99^{cd}	8.30^{a}	11.37^{d}	9.97^{bcd}	8.89^{ab}	9.71^{abc}	0.16
N balance (g/d)							
N intake	9.98^{d}	2.98^{a}	8.14^{b}	14.54^{e}	9.30^{c}	8.15^{b}	0.04
Fecal N	4.42^{b}	1.71^{a}	3.63^{b}	4.60^{b}	4.78^{b}	3.72^{b}	0.12
Urine N	3.79^{bc}	0.95^{a}	2.82^{b}	7.22^{d}	2.73^{b}	4.03^{c}	0.08
N balance	1.77^{ab}	0.32^{a}	1.68^{ab}	2.72^{b}	1.78^{ab}	0.40^{a}	0.17

[a,b,c]Means with different superscripts in a row differ significantly (*P<0.01); T-1;FBPW+CFM+ RGS; T-2;FBPWS+RGS; T3:FBPWS+CFM+RGS; T-4:FBPWS+SBM+RGS;T-5;FBPWS+Maize+SRNP+RGS;T-6FBPWS+Wheat bran+RGS

concentrate feed. It is indicated that FBPWS had good quality digestible fractions.In all groups, the digestibility of different nutrients obtained in the study were higher than the values reported by Hambade and Patel (2004) for banana plant leaves and lower than the values reported by Ginni (2014) for banana pseudostem based diets in goats.

DCP and TDN of FBPWS based diet was slightly higher than roughages commonly used in ruminant feeding. Diet comprising of silage alone had lower (P<0.01) digestible crude protein (DCP) (3.08%) like any other roughage diet, but T_4 had DCP value of 15.13 % due to higher CP content in SBM. The silage based diet (T_3) had better DCP value as compared to T_1 which was supplemented with same CFM. The FBPWS based diet had TDN of 54.87 % which was similar to TDN content of any roughage. It is clear that the TDN value of any feedstuff depends on the intake of digestible nutrient. The TDN level in diets T_1 and $T_3$was higher (P<0.01) than other concentrate supplemented groups possibly due to associative effect of feedstuffs. The T_2 diet had supported slightly above maintenance level (16 g/d) of nutrient requirement of goats whereas the FBPW supplemented with CFM supported for around 66 g/d and silage supplemented with either CFM or any concentrate ingredients supported 80% of gain that was achieved in FBPW fed group.Among different treatments T_1 and T_4 have achieved highest weight gain.This was well supported by positive nitrogen balance in all groups. Several studies that fed different level of FBPW and its silage in different experiments in bullock and bulls reported positive nitrogen balance (Gupta *et al*., 2001; Rahman and Haque, 2002).

Data pertaining to serum total protein, albumin, globulin,albumin: globulin and serum urea nitrogen are presented in Table 3. Different levels of concentrate supplements included to FBPW and FBPWS based diet could not influence any of the serum biochemical parameters in experimental goats. All values were in the normal range which suggested that the experimental diet had little influence on serum biochemical parameters. Similar findings were also reported by Khattab *et al.* (2000) for silage and Ally and Kunzikutty (2003) for fresh banana plant waste.

CONCLUSIONS

It was concluded that FBPW based diet can be

Table 3. Serum biochemical parameters in different groups of experimental goats

Parameter	T_1	T_2	T_3	T_4	T_5	T_6	SEM	P
Total protein (g/dl)								
Initial	7.55	6.76	7.31	7.04	7.16	7.13		NS
Final	7.40	6.99	7.54	7.16	7.21	7.26	-	NS
Albumin (g/dl)								
Initial	2.07	2.14	1.86	2.13	2.08	2.18	-	NS
Final	2.22	2.25	2.15	2.21	2.29	2.27	-	NS
Globulin (g/dl)								
Initial	5.48	4.62	5.45	4.92	5.08	4.95	-	NS
Final	5.17	4.74	5.38	4.95	4.92	4.98	-	NS
Albumin: globulin								
Initial	2.67	2.19	3.06	2.33	2.48	2.30	-	NS
Final	2.36	2.14	2.50	2.27	2.16	2.23	-	NS
Serum urea nitrogen (g/dl)								
Initial	13.08	12.73	13.19	13.67	13.09	13.51	-	NS
Final	13.30	13.26	13.20	14.00	13.10	13.60	-	NS

T-1;FBPW+CFM+ RGS; T-2;FBPWS+RGS;T3:FBPWS+CFM+RGS; T-4:FBPWS+SBM+RGS;T-5;FBPWS+Maize+SRNP+RGS; T-6FBPWS+Wheat bran+RGS

comparable to conventional diets with respect to crude protein except T_2 which was a sole roughage diet and T_5 diet which had SBM as a source of protein. FBPW and FBPWS based diet can support slightly above maintenance requirement, when it was supplemented with RGS. Supplementation of FBPW with CFM and FBPWS with SBM based diets were superior over remaining silage based diets in terms of achieving higher body weight gain. Further, silage consumption either alone or as proportion of diet can be increased by incorporating more cereal grain and dry roughage as moisture absorbents.

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Received on 03-09-2018 and accepted on 17-02-2019

Indian J. Anim. Nutr. 2019. 36 (2): 158-163
doi: 10.5958/2231-6744.2019.00027.6

Indian Journal of Animal Nutrition

An Economic Analysis of Milk Production of Buffalo and Cow in Rajasthan

G.L. Meena*, Latika Sharma, Siddhartha Mishra and Suraj Choudhary
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture & Technology, Udaipur, 313001, Rajasthan, India

ABSTRACT

The present study was conducted in Rajasthan during the year 2017-18. An attempt has been made in this investigation to work out the cost and returns from milk production across different milch species of animals. The study covered 60 dairy households from Jaipur and Alwar districts.The results of the study revealed that the average size of herd (standard animal units) of households surveyed was 6.68 and majority of them were buffalo followed by young stock, crossbred cow and local cow. Average investment per household was ₹ 2,69,455 per annum and the major expenditure was on milch animals (₹ 1,98,842) followed by cattle shed and stores (₹ 59,475) and dairy equipments (₹ 11,138). Average milk yield per day per animal was highest for crossbred cow (7.22 litres) followed by buffalo (5.49 litres) and local cow (3.98 litres). Net maintenance cost per milch animal per day was found to be relatively higher in case of crossbred cow (₹ 151.51) followed by buffalo (₹ 148.91) and local cow (₹ 119.68). The per litre cost of milk production was observed to be higher in case of local cow (₹ 30.07) followed by buffalo (₹ 27.12,) and crossbred cow (₹ 21.04).The net income per day was relatively higher in case of buffalo (₹ 73.44) as compared to crossbred cow (₹ 23.18), while it was found negative for local cow (-4.86).

Key words: Buffalo, Cow, Investment pattern, Maintenance cost, Net income, Rajasthan

INTRODUCTION

Livestock farming in Rajasthan state is closely interwoven with agriculture and plays an important role in determining the rural economy by providing gainful employment to small and marginal farmers, agriculture laborers, farm women and other deprived groups. Rajasthan is the second largest milk producing state (with share of 12.61 per cent to total milk production of India) in the country where per capita per day availability of milk was 785 grams (NDDB, 2016-2017). Rajasthan is the only state in India where the local breeds of animal are abundantly available. The buffaloes and cows are the primary sources of milk.

Few outstanding research work on the economics of milk production has been conducted earlier by the different researchers such as Bairwa (2004), Singh (2005), Meena *et al.* (2010), Chand and Sirohi (2012) in Rajasthan while Singh *et al.* (1994) and Shiyani and Singh (1995), Kalra *et al.* (1995), Singh and Agrawal (2007), Bardhan and Sharma (2012), Sunil *et al.* (2016) and Chand *et al.* (2017) studied economics of milk production at different part of the country. But economics of milk production differs from region to region and district to district, animal to animal and year to year.

Production cost, at given level of prices, plays an important role in portraying economic viability of a dairy enterprise. It is a critical economic indicator for milk producers, consumers and policy makers in order to provide an effective linkage between the milk producers and consumers for fixing the price of milk rationally. Generally, a milk producer can increase his daily income in two ways either by increasing the milk production or by reducing cost of milk production. Cost of milk production often becomes a policy issue, when milk producers complain that the price of milk they are getting does not the cover cost of milk production. In view of the overwhelming importance of the milk production in devising the rural economy of Rajasthan, the present investigation was carried out and an attempt has been made to work out the cost and returns from milk production.

MATERIALS AND METHODS

The study pertains to the state of Rajasthan.The Jaipur and Alwar districts were selected purposively from Rajasthan on the basis of highest livestock

*Corresponding author E-mail:glm57@rediffmail.com

population. These two districts contribute approximately 11 per cent of total livestock population of the state.These two districts shared about 24.17 per cent of the registered Dairy Cooperative Societies in the year 2016-17. From each selected district, two tehsils were selected randomly. From each tehsil, one village was selected randomly. Thus, Amar and Mozamabad tehsils from Jaipur district and Kishangarhbas and Mandawar tehsils from Alwar district were selected randomly. The village Sirsali and Mokhampura from Jaipur district and Ghasoliand Mator from Alwar district were selected randomly. Total four tehsils and four villages of two selected districts were taken in sample. The final sampling unit was dairy household. From each selected village, 15 dairy households having at least one lactating animal were selected randomly. Thus, a total of 60 dairy households were randomly selected for the present study.The study was based on primary data which were collected with the help of well-structured pre-tested schedule by personal interview method. This study was conducted during the year 2017-18.

Certain expenses were incurred by the farmers for the entire herd on the farm. Fixed assets like cattle shed; other fixed equipments and miscellaneous items are jointly used for animals of all age groups of either sex. Hence, the total expenses of a household on the joint cost items; depreciation and interest on fixed assets (other than value of milch animal that is animal specific), human labour, miscellaneous cost were apportioned on the basis of standard animal units (SAUs) as suggested by Kumbhare *et al.* (1983). The depreciation on milch local cows, crossbred cows and buffaloes were calculated by straight line method and rates of deprecation were considered as 12, 8 and 10 per cent, respectively, assuming a productive life of 8 years for local cows, 12 years for crossbred cows and 10 years for buffaloes. The depreciation for other fixed assets was taken based on the appropriate assumptions regarding their useful economic life.

The overall maintenance cost of milk production is an aggregate of expenditure incurred on the fixed and variable items. Net cost was obtained by subtracting the imputed value of dung from the gross cost. The net cost of maintenance per milch animal per day was divided by the respective average milk yield per milch animal per day to arrive at per litre cost of milk production. Various cost concepts and income measures were employed given as under.

Returns from milk production: The gross returns considered to take into account two items *i.e.* milk and dung. The sale of calves and/or adult animals was not taking into account in calculation of return. The following cost concepts and income measures were computed.

Cost A = Expenditure on feeds and fodders (+) Veterinary expenditure (+) Expenses on hired human labour (+) Miscellaneous expenditure (+) De preciation on fixed assets

Cost B= Cost A (+) Interest on fixed capital

Cost C= Cost B (+) Imputed value of family labour

Gross Income = (Quantity of milk * Prevailing price of milk + Quantity of dung * Price of dung)

Farm business income = Gross Income - Cost A

Family labour income = Gross Income - Cost B

Net income = Gross Income - Cost C

RESULTS AND DISCUSSION

The herd strength and the number of milch animals in the household directly affect the economy of the milk producers. Different breeds, species and types of animals were maintained in various households. The herd size maintained by households was converted into standard animal units using the conversion factors suggested by Kumbhare *et al.* (1983) and same is presented in Table 1. On an average, a milk producer household maintained a herd size of 6.68 standard animal units which consisting of 3.68, 0.72, 0.37 and 1.91 standard animal units of buffalo, crossbred cow, local cow and young stock in study area. There was no draught animal due to the adoption of farm mechanization. It is clear that milk producer households were having more buffalo as compared to crossbred cow and local cow in livestock resource.

Table 1: Average size of herd (Standard Animal Units)

Milch animals			Young stocks	Total
Buffalo	**Cross bred cow**	**Local cow**		
3.68 (55.08)	0.72 (10.78)	0.37 (5.54)	1.91 (28.59)	6.68 (100.00)

Figures in parentheses indicate the percentages of the total Standard Animal Units.

The investment on different items like cattle shed and stores, dairy equipments and dairy animals was worked out and presented in Table 2. A close perusal of the table revealed that total investment per household in dairy enterprise was ₹ 2,69,455. Nearly 74 per cent of the total investment was incurred on milch animals followed by 22 per cent on cattle shed and stores and the balance 4 per cent on dairy equipments. A similar finding of investment pattern was also observed by Meena (2008) in Alwar district of Rajasthan. Since investment pattern depends upon the number of animals of different types maintained in a household, a comparison of investment made for milch animals is possible only in terms of standard animal units. Investment per standard animal unit in dairy enterprise was ₹ 40,337.57.

The ultimate objective of any dairy development programme is to attain increased income level of the milk producers through higher average milk yield of milch animals. It is evident from the table that the average milk yield per day per animal was highest for crossbred cows (7.22 litres) followed by buffaloes (5.49 litres) and local cows (3.98 litres). The state average milk yield was 7.78 litres for crossbred cows, 4.75 litres for buffaloes and 3.44 for local cows (Government of Rajasthan, Directorate of Animal Husbandry, Jaipur). The productivity of buffaloes and local cows in study area was higher as compared to state average milk yield, while it was lower in case of crossbred cows.

In order to understand milk production from its economic perspective, it is essential to study the costs, be it implicit or explicit that goes into its production. The analysis of cost of milk production across the milch species forms an important aspect in bovine husbandry. The comparative analysis of overall average daily maintenance cost for buffaloes and cows is presented in Table 4. A perusal of the data revealed that the overall average per day net maintenance cost per milch animal was found to be ₹ 148.91 for buffalo, ₹ 151.51 for crossbred cow and ₹ 119.68 for local cow. The results of study revealed that net maintenance cost was higher in crossbred cows followed by buffaloes and local cows. These results are in line with the findings observed by Sirohi *et al.* (2007), Lal and Chandel, (2016), Sonawane (2016), Sunil *et al.* (2016) and Chand *et al.* (2017) while Bairwa (2004) found higher maintenance cost in buffaloes followed by crossbred cows and local cows. The component wise analysis of maintenance cost indicated that fixed and variable costs accounted for 17.53 and 82.47 per cent in case of buffaloes, 20.05 and 79.95 per cent in case of crossbred cows, and 18.09 and 81.91 per cent in case of local cows, respectively of gross cost. Sharma and Singh (1994) and Kalra *et al.* (1995) also observed the share of variable and fixed cost to be approximately 85 and 15 per cent of gross cost respectively. The component wise break-up of variable cost component indicated that the feed cost accounted for 56.73 per cent of gross cost for buffaloes, 52.80 per cent for crossbred cows and 55.01 per cent for local cow. Singh *et al.* (1994) and Shiyani and Singh (1995) also observed that feed cost accounted for 55 to 70 per cent of the gross cost in the case of buffaloes. The share of labour cost in gross cost was found to be almost similar at 24.10 per cent for

Table 2: Investment Pattern in dairying

Items	Rupees per annum
1. Cattle shed and stores	59,475 (22.08)
2. Dairy equipments	11,138 (4.13)
3. Milch animals	1,98,842 (73.79)
Investment per household	2,69,455 (100.00)
Investment per Standard Animal Unit	40,337.57

Figures in parentheses indicate the percentages of the total investment per household.

Table 3. Average milk yield of milch animals

Animals	Litres/animal/day
Buffalo	5.49
Crossbred cow	7.22
Local cow	3.98

buffaloes, 25.18 per cent for crossbred cows and 25.36 per cent for local cows. Thus, it can be concluded from the study, by keeping maintenance cost in view, that rearing of crossbred cows was costly as compared to buffaloes and local cows.

Cost of milk production per unit is an important indicator of efficiency of milk production. A major issue in fixation of milk prices is whether, the milk price should be fixed on the basis of total cost of milk production, which entails the value of family labour computed at the on-going wage rates for permanent farm labour or only for the paid out costs, which naturally excludes a major chunk of unpaid costs. Under these circumstances, an attempt has been made in this study to compute maintenance cost of milk production inclusive and exclusive of family labour and fixed cost. A comparative analysis of maintenance cost, per litre cost of milk production and various income measures for buffaloes and cows have been presented in Table 5.

A perusal of the data revealed that the overall average Cost-A, Cost-B and Cost-C per milch animal per day for buffalo milk production were observed to ₹ 112.41, ₹ 131.93 and ₹ 173.82 while corresponding costs were ₹ 105.52, ₹ 127.13 and ₹ 169.91 for crossbred cow and ₹ 86.18, ₹ 101.40 and ₹ 135.85 for local cow. The overall average net income per day was ₹ 73.44, ₹ 23.18, and ₹ (-) 4.86 for buffaloes, crossbred cows and local cows, respectively. Daily net income was positive for buffalo and crossbred cow while it was negative for local cow. Similar finding of negative returns in case of local cattle was also reported in earlier studies by several authors (Singh and Agrawal, 2007;Bardhan and Sharma, 2012; Singh *et al.* 2012; Chand and Sirohi, 2012).

On an average, the per litre cost of milk production for buffaloes, crossbred cows and local cows

Table 4: Average net maintenance cost of buffaloes, crossbred and local cows

(₹/milch animal/day)

Items of cost	Buffalo	Share to gross cost (%)	Crossbred cow	Share to gross cost (%)	Local cow	Share to gross cost (%)
Fixed Cost :						
Depreciation on fixed assets	10.95	6.30	12.45	7.33	9.35	6.88
Interest on fixed assets	19.52	11.23	21.61	12.72	15.22	11.20
(A) Total Fixed Cost	30.47	17.53	34.06	20.05	24.57	18.09
Variable Cost :						
Green fodder	23.38	13.45	21.80	12.83	18.86	13.88
Dry fodder	47.69	27.44	43.62	25.67	38.23	28.14
Concentrate	27.54	15.84	24.30	14.30	17.64	12.98
Total feed cost	98.61	56.73	89.72	52.80	74.73	55.01
Family labour	41.89	24.10	42.78	25.18	34.45	25.36
Veterinary and	2.85	1.64	3.35	1.97	2.10	1.55
miscellaneous expenditure	2.85	1.64	3.35	1.97	2.10	1.55
(B) Total Variable Cost	143.35	82.47	135.85	79.95	111.28	81.91
Gross Cost (A+B)	173.82	100.00	169.91	100.00	135.85	100.00
(C) Value of dung	24.92	-	18.41	-	16.17	-
Net Cost (A+B-C)	148.91	-	151.51	-	119.68	-

Table 5: Cost of milk production and income measures for milch animals

(₹ /milch animal/day)

A. Cost Concepts	Buffalo	Crossbred cow	Local cow
1. Expenditure on feed and fodders	98.61	89.72	74.73
2. Veterinary and miscellaneous expenditure	2.85	3.35	2.10
3. Imputed value of family labour	41.89	42.78	34.45
4. Depreciation on fixed assets	10.95	12.45	9.35
5. Interest on fixed investment	19.52	21.61	15.22
6. Cost-A = 1+2+4	112.41	105.52	86.18
7. Cost-B = Cost-A+ interest on fixed investment	131.93	127.13	101.40
8. Cost-C = Cost-B+imputed value of family labour	173.82	169.91	135.85
B. Income Measures			
9. Gross income (milk + dung)	247.26	211.54	130.99
10. Farm businessincome = 9-6	134.85	106.02	44.81
11. Family labourincome = 9-7	115.33	84.41	29.59
12. Net income = 9-8	73.44	41.63	-4.86
C. Per litre cost of milk production	**27.12**	**21.04**	**30.07**

was ₹ 27.12, ₹ 21.04 and ₹ 30.07, respectively. Thus, it can be concluded from this study that the per litre cost of milk production was higher in case of local cows followed by buffaloes and crossbred cows. This finding is in line with the observation of Kalra *et al.* (1995). Thus, the results clearly indicate that by keeping net income in view, that buffalo keeping was more profitable than crossbred cow and local cow.

CONCLUSIONS

It may be concluded from the study that the total variable cost of milk production of milch animals varied from 17.53 per cent in buffaloes to 20.05 per cent in crossbred cows. Per animal per day feeding cost ranged from 52.80 per cent in crossbred cow to 56.73 per cent in buffalo of the total cost for dairy animals. The feed and fodders accounted for a major part of the total cost followed by human labour. The per litre cost of local cow milk was high as compared to buffalo and crossbred cows due to lower milk yield of local cows. The cost of milk production and income measures obtained in the present study revealed that buffalo milk production was relatively more profitable than crossbred cow in the study area while rearing of local cow was not profitable in study area. Thus, sound economic logic exists for persuading dairy households to continue buffalo as well as crossbred cow rearing to enhance their income from milk production and there is need for improvement in the local non descript / indigenous cows to increase milk productivity. The local cows are more adaptive to climate change. Therefore, instead of ignoring local cow they may be upgraded to recognized indigenous breed and further genetic improvement is required for economic traits.

ACKNOWLEDGEMENTS

This paper is a part of ICAR- NIAP net-work project on Resource Use Planning for Sustainable Agriculture. The authors thank ICAR- NIAP for providing financial assistance.

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Received on 13-02-2019 and accepted on 12-06-2019

Indian J. Anim. Nutr. 2019. 36 (2): 164-172
doi: 10.5958/2231-6744.2019.00028.8

Indian Journal of Animal Nutrition

Variation in Straw Grain Ratio and Straw Quality in Different Rice Cultivars of India

M.M. Das[1*], A.K. Misra[2], K.K. Singh[3], G.H. Pailan[4] and T.A. Khan[5]
ICAR- Indian Grassland and Fodder Research Institute, Jhansi-284003, Uttar Pradesh, India

ABSTRACT

Straw grain ratio (S/G ratio) of paddy cultivars available across the country in different states was determined. Variation in straw quality was also estimated. Sampling locations were from farmers field spread over 9 major paddy producing states *viz.*, Bihar, Chhatishgarh, Gujrat, Haryana, Jharkhand, Tamilnadu, Uttar Pradesh, Uttrakhand and West Bengal. A significant variation (P<0.001) in straw to grain ratio was recorded among the paddy cultivars grown by the farmers in different states.Variability(P<0.05) within cultivar was also observed among cultivars grown under different agro-climatic regions and agronomical practices. Similarly, significant variations (P<0.01) quality attributes *viz.*, CP, NDF, ADF, hemicelluloses, cellulose and lignin content was recorded among the paddy cultivars. Among the various chemical constituents, the lignin content varied greatly (126%) followed by CP(76.15%), hemicelluloses(72.34%), cellulose (37.67%), ADF (25.39%), and NDF (15.48%). The DM degradability of straw from different paddy cultivars ranged from 35 to 64.4%, whereas, NDF digestibility varied from 63.52 to 80.74 %. NBDMD was negatively correlated with ADF and lignin content of straw.It can be concluded that the variability in nutritional parameters among varieties /cultivars need to be exploited by plant breeders, particularly in paddy growing areas where paddy straw is a major roughage source for ruminant diet.

Key words: Agro-climatic regions, Chemical composition, Nylon bag degradability, Paddy cultivars, Straw grain ratio

INTRODUCTION

Rice straw is abundantly available from cultivating rice, farmers offer rice straw as the main roughage source to their animals especially in eastern and southern region of the country.In India, ruminants depend on year-round grazing on natural pastures or they are fed with cut grasses and crop residues. India occupies the world's largest area under rice, grown under a wide range of agro-ecological conditions, the second-largest producer and consumer of rice in the world and accounts for 22.3% of global production. The share of paddy in total food grain production in India is around 41.36 % and share in acreage is about 35.39 % of the total area under food grains (Annual report 2016-17).According to Mandal *et al.* (2004), the total amount of crop residue generated in India is estimated at 350×106 kg/year of which wheat residue constitutes about 27 % and rice residue about 51 %. Production of crop residues is most commonly expressed as straw:grain (S:G) ratios. Variability of environmental and agronomic factors greatly influence the crop residue production (Norton *et al.,* 2017).

The land under green fodder cultivation in the country is decreasing day by day and the farmers of the paddy growing areas will be more dependent on the crop residues specially the paddy straws for feeding their livestock. Therefore, there is a need for systematic evaluation of the nutritive values of different cultivars/varieties of rice straw to develop a feeding system for its efficient utilization and exploitation of variation in nutritional attributes among varieties / cultivars by plant breeders,. The present study was undertaken to determine the straw: grain ratio, the chemical composition and *in sacco*-degradability of different varieties of rice straw.

MATERIALS AND METHODS

The sampling locations were the farmer's field spread over 9 major paddy producing states (Bihar,

[1,2,3]Plant Animal Relationship Division, ICAR-Indian Grassland and Fodder Research institute, Jhansi, Uttar Pradesh 284003, India; [4]ICAR-Central institute of fisheries Education, Salt Lake, Kolkata, India; [5]Retired Scientist, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, India; [*]Corresponding author:E-mail:mmdas1964@gmail.com

Chhatishgarh, Gujrat, Haryana, Jharkhand, Tamilnadu, Uttar Pradesh, Uttrakhand and West Bengal. Multi-stage random sampling procedure was adopted for sampling and representative plant samples were collected following the standard procedure (Snedecor and Cochran, 1967). Hand sickles were used to harvest the above ground plant biomass. All hand-clipped samples collected from 10 different locations of the field were placed in a paper sack and then dried in an oven at 50°C and then thrashed to determine grain yield, straw yield, and straw/grain ratios. After determination of straw yield, the plant samples of 10 different locations of each field were pooled together for chemical analysis.

The plant samples were dried at 60 to 70°C and ground to pass through 1mm sieve and analysed. The OM was determined by ashing at 550°C for 4 h and nitrogen was determined by Kjeldahl technique (AOAC, 2000). Neutral detergent fibre (NDF) and acid-detergent fibre (ADF) were determined by a procedure of Van Soest *et al.* (1991). Acid-detergent lignin (ADL) was determined according to the method described by Robertson and Van Soest, (1981).

Two buffalo calves (335+12.5 kg BW and 36-40 months of age) fitted with rumen cannulae were used *in sacco* degradability trial. Calves were maintained on wheat straw-based diet (roughage to concentrate ratio, 65:35). The paddy straw samples were ground through 1 mm sieves before *in sacco* rumen incubation. Triplicate samples of 2.5 g DM of each test straw were weighed in to separate nylon bags. Nylon bags were suspended in the rumen as per the method described by Mehrez and Ørskov (1977) for 48 h. After incubation, the bags with residues were taken out from rumen, dipped immediately into cold water to stop the microbial activity and then rinsed with cold water to remove the particles from outside the bags. There after the bags were washed in a washing machine for 15 minutes. The bags were dried at 45°C till the constant weights were achieved.Statistical analyses, including ANOVA and Pearson correlation analysis (Snedecor and Cochran, 1968) were performed with SPSS13.0 (SPSS software products, 1997, USA).

RESULTS AND DISCUSSION

Straw/grain (S/G) ratios varied greatly (P<0.01) among the states and also within the states covered for sampling (Table 1). Average S/G ratios ranged from 0.75(Haryana) to 1.76(Bihar). Varietal variations (P<0.01) in S/G ratios were also evident in the samples collected from different locations (Table 2). Mean S/G ratios were observed highest for the variety Lok 355(2.35) and the lowest for Purnima (0.73). However,Schiere *et al.*(2004) reported straw to grain ratio of 1.6 in rice crop. These ratios were affected by the phenotypic, genotypic and environmental factors (Khaire *et al.,* 2017). Straw/grain ratios were generally increased by available soil N levels (Kumar *et al.,* 2005).

Table 1. Straw to grain ratios (kg straw/kg grain) in paddy cultivars grown in different parts of India

State (n)	Average S/G ratio	Range	SEM
Bihar (34)	1.76	0.90-2.91	0.07
Gujarat (50)	1.06	0.60-1.72	0.04
Chhattisgarh (100)	1.54	0.74-3.33	0.06
Haryana (120)	0.75	0.29-1.97	0.02
Jharkhand (360)	1.03	0.40-4.33	0.02
Uttar Pradesh (250)	1.37	0.33-3.81	0.03
West Bengal (150)	1.28	0.54-3.57	0.04
Uttrakhand (80)	1.24	0.78-2.24	0.04
Tamilnadu (140)	1.16	0.52-2.25	0.03
P value	0.001**	-	

Figures in parenthesis indicate the number of sampling locations; P= Statistical significance; **= P<0.01; SEM= Standard error of means

Table 2. Varietal variations in straw to grain ratios (kg straw/kg grain) in paddy cultivars

Paddy cultivars[1]	Sample size	Mean	Range
Ad2235	10	1.32	0.85-1.81
Ad97191	10	1.34	1.13-1.80
Ad99039	10	1.33	0.97-1.91
AD9910	10	1.6	1.34-1.88
ADT38	10	1.02	0.80-1.26
Basmati 30	10	2.14	2.12-2.21
Basmati local	50	1.98	0.87-3.33
Basmati370	10	2.05	2.03-2.24
Bhagirathi	10	1.78	1.57-2.21
BirsaMoti	10	1.26	1.13-1.66
BPT 5204	20	1.49	0.91-2.31
CR 1017	20	1.48	0.99-1.97
CR1009	80	1.03	0.52-2.25
Cr1010	10	1.45	1.10-2.12
Doon hybrid	10	1.27	1.15-1.61
Dwarf mansoori 7029	30	1.27	0.86-1.63
Giri	10	2.16	1.35-3.57
GR4	10	1.06	0.89-1.36
Gurjari	20	0.98	0.60-1.46
IET1444	10	1.18	0.86-2.19
IET4094	10	0.98	0.75-1.27
IR 36	20	1.08	0.82-1.59
IR64	50	1.07	0.40-2.23
Lalat	50	0.91	0.61-1.51
Local	50	1.31	0.81-2.10
Lok 355	10	2.35	2.04-2.98
Mahamaya	20	0.79	0.55-1.31
MTU 7029	20	1.19	0.80-1.46
MUT1010	60	0.74	0.29-1.97
PA6444 Proagro hybrid	60	0.82	0.58-1.50
Parimal	9	2.06	1.48-2.91
PHB 71	60	0.83	0.47-1.98
PR 4	40	1.1	0.74-2.16
Purinma	20	0.73	0.53-1.46
Pusa 1001	10	1.11	0.88-1.54
Pusa 831	5	1.7	1.20-2.24
Pusa RH 10	14	1.5	0.90-1.85
Ranjit	10	0.8	0.68-1.06
S 52	10	1.57	0.94-2.20
Sarbati	10	0.98	0.92-0.99

Saryu 52	140	1.3	0.33-3.81
Savita	10	1.8	1.27-2.64
Sita	20	1	0.72-1.65
Sugandha	10	1.21	0.93-1.37
Sugandha 3	6	1.68	1.42-2.18
Sugandha 5	5	1.84	1.52-2.14
Sugandha2	5	1.87	1.67-2.15
Suruchi	10	0.84	0.70-1.22
Swarna	70	1.08	0.54-4.33
Swarna white	20	1.21	0.97-2.05
Type 3	10	1.87	1.51-3.08
VL Dhan207	70	1.13	0.78-1.81
White punny	10	1.4	1.16-1.99
Pvalue		*	
SEM		0.21	

SEM= Standard error of means; *= P<0.05; [1]Name of paddy cultivars are based on information provided by the farmers during sample collection

Tingxian *et al.*(1993) observed great differences in plant height and grain yield at differently matured varieties. They also observed that plant height and grain yield is much higher in medium maturing rice than early maturing rice varieties.

Straw quality parameters of different paddy cultivars are presented in Table 3 and 4. Significant variations (P<0.01) in all the quality attributes *viz.*, CP, NDF, ADF, hemi cellulose, cellulose and lignin were observed among the paddy cultivars.Among the various chemical constituents, the lignin content varied greatly (126%) followed by CP (76.15%), hemicelluloses (72.34%), cellulose (37.67%), ADF (25.39%), and NDF (15.48%). These large variations among quality attributes of some paddy cultivars have already been reported earlier by Peripolli *et al.* (2016). Nader *et al.* (2012) also observed substantial variability in the nutrient levels and feeding value among rice straws because the nutritional value of the straw is directly related to its chemical composition, combined with genetic factors (Capper, 1988), climate (Sannasgala and Jayasuriya, 1986), morphological composition (Nakashima and Orskov,1990) and cultivation practices such as fertilizer application, water management, harvest maturing stage (Ibrahim *et al.,* 1988). Nori *et al.* (2006) reported great variability in chemical composition among rice straws. Tingxian *et al* . (1993) also observed that NDF content of medium maturing rice was significantly higher than that of early maturing and late maturing varieties.The lignin content of early maturing rice straw was significantly less than that of medium, and late maturing varieties. Rice straw from more productive cultivars had lower levels of lignin and C fraction as well as higher levels of crude protein and B3 fraction compared to straws from less productive cultivars. Perpolli *et al.*(2016) observed that straws derived from early maturing cultivars showed the lowest levels of neutral detergent fiber, acid detergent fiber, acid detergent insoluble nitrogen and C nitrogen fraction in comparison with straw originating from mid cycle cultivars.

Much of the variations observed may also be due to differences in the proportions of plant morphological fractions, rather than differences in cell wall composition *per se*.In medium and late maturing varieties the proportion of leaf sheath is higher than leaf blade and followed by stem (Tingxian *et al.,*1993). Combined leaf blade and leaf sheath constituted about 75% of the total rice straw. Nori (2005) also reported great variability in proportion of morphological fractions

Table 3. Variability in nutrient content (% DM basis) and DM degradability (%NBDMD) of straw of different paddy cultivars grown in various regions

Paddy cultivar	CP	NDF	ADF	HC	Cellulose	Lignin	NBDMD
Basmati 30	3.25	63.99	45.22	18.77	37.95	6.13	53.07
Basmati local	-	70.4	46.92	23.49	37.65	8.53	58.44
Basmati370	4	69.99	47.26	22.73	41	6.11	50.74
Bhagirathi	3.56	74.59	48.51	26.08	36.16	8	49.89
BirsaMoti	3.49	70.37	51.06	19.3	40.39	7	64.91
BPT 5204	3.38	71.92	41.36	30.56	35	13.23	66.79
CR 1017	3.58	73.49	48.35	25.15	36.42	7	48.95
Cr1010	3.67	72.14	49.15	22.98	38.12	7	49.52
Doon hybrid	3.02	73.18	46.58	26.6	36.23	10.6	66.4
Dwarf mansoori 7029	4.41	70.88	47.18	23.69	38.14	11.93	49.03
Giri	3.89	69.97	48.2	21.77	35.23	8	49.56
GR4	5.32	72.5	52	20.5	32.24	7.5	48.02
Gurjari	5.02	71.11	46.91	24.21	29.78	7.76	55.76
IET1444	3.98	68.75	44.48	24.27	35	7.32	50.05
IET4094	3.86	72.97	51	21.97	37.43	8	51.02
IR 36	3.44	69.98	46.95	23.03	34.55	7.77	60.41
IR64	3.53	70.88	45.74	25.14	35.29	7.14	60.33
Lalat	4.07	70.41	51.22	19.19	38.88	7.8	50.11
Local	2.99	68.67	46.68	21.99	35.29	7.68	50.03
Lok 355	3.84	74.5	35.68	38.82	35	13.59	61.24
Mahamaya	3.6	71.33	51.86	19.48	35.48	8	44.61
MTU 7029	3.08	72.65	45.5	27.15	36.2	10.96	59.67
MUT1010	3.15	71.42	50.38	21.04	34.33	8	48.56
PA6444 Proagro hybrid	3.41	72.22	44.71	27.52	36.5	7.04	59.76
Parimal	5.18	68.92	47.54	21.38	36.48	7.33	55.91
PHB 71	3.45	73.9	46.83	27.08	37.21	8.29	57.77
PR 4	4.5	70.09	47.22	22.87	36.88	7.96	62.06
Purinma	3.63	72.97	49.89	23.09	33.9	8	45.97
Pusa 1001	3.86	68.23	45.11	23.11	32.98	5	53.42
Pusa 831	4.8	68.29	51.5	16.79	36.38	8	52.72
Pusa RH 10	4.73	69.79	49.01	20.78	35.81	8	58.44
Ranjit	3.89	70.55	47.88	22.67	35.1	8	50.21
S 52	4.31	69.25	45	24.25	35	11.32	61.26
Sarbati	4	68.28	45.31	22.97	34.98	13.81	53.2
Saryu 52	4.38	70.59	45.39	25.2	35.87	8.18	59.76
Savita	3.89	69.79	48.57	21.22	36.29	8	50.21
Sita	3.76	70.98	51.84	19.15	39.21	8	57.84
Sugandha	5.67	69.33	48.06	21.27	35.73	8	52.93
Sugandha 3	4.5	69.51	50.8	18.71	35.79	5.92	52.36

Sugandha 5	4.56	69.46	50.86	18.6	35.63	6.28	58.87
Sugandha 2	4.6	68.43	48.75	19.67	36.36	8	54.56
Suruchi	3.37	72.35	40	32.35	40.43	7	58.33
Swarna	3.98	73.24	49.05	24.19	35.97	7.65	56.71
Swarna white	3.76	72.99	49.82	23.17	37.68	8	49.89
Type 3	3.5	68.87	45	23.87	35	12.85	63.91
VL Dhan 207	389	69.83	45.8	24.03	37.29	11.03	44.87
P	*	*	**		**	**	*
SEM	0.2	1.81	1.17	1.1	1.03	0.77	1.44

P= Statistical significance; SEM= Standard error of means; *P<0.05, **= P<0.01

in rice straws. The concentration of straw nitrogen was significantly affected by the site where the rice plants were grown, if they were grown under alternate wetting and drying or continuous flooding,difference was significant among the cultivars (Norton *et al.*2017).

Results of micro and macro nutrient analysis (Table 5 and 6) of rice straw samples indicated that calcium content was sufficient (0.49 to 0.88%) to meet the requirements of dairy animals. However, phosphorus (0.03-0.15%) was deficient in samples collected from all the states except Uttarakhand (0.22%) as compared to its required level (0.22 %).Norton *et al.*(2017) recorded that the concentration of straw phosphorus was 0.03-0.06% among different rice cultivars and was significantly affected by site, treatment, and cultivar as well as interactions between site × treatment and site × cultivar. Similarly, magnesium content was also low (0.06-0.1%) in major rice producing area as compared to its required level (0.20 %). The copper content of rice straw samples ranged from 4.88 to 7.78 ppm, which was considered low in meeting the dietary requirement. Dash *et al.* (2010) reported higher Cu content (7.9-14.43 ppm) in paddy straw with application of inorganic and organic sources of N. Likewise, zinc content was also low and it varied greatly (12.46 to 28.83 ppm) among rice straw samples and corroborated with the findings of Dash *et al.* (2010).Lakshmanan *et al.* (2005), however,reported 50-94.7 ppm Zn in straws of different varieties of basmati rice and Norton *et al.* (2017) recorded the Zn concentration of 18.54-61.04 ppm in different cultivars of paddy straws grown in different sites. The concentration of iron and manganese, however, in rice straw samples were many folds higher than their required levels of 50 and 40 ppm, respectively.

A significant (P<0.01) variability (35.0 to 64.4 percent) in *in sacco* straw DM disappearance was observed (Table 7) among different rice cultivars. Agbagla *et al. (*2003) reported DM degradability in the range of 41.7-47.8% in different rice varieties. Nori *et al.* (2006) observed great variability in *in vitro* digestibility of rice straw cultivars. Tingxian *et al.* (1993)

Table 4. Fibre, protein and DM (NBDMD) degradability (% of DM) of straw of paddy cultivars collected from different locations

Attribute	n	Mean	Minimum	Maximum	SEM	SD
NDF	162	72.1	63.52	80.74	0.24	3.1
ADF	162	48.38	35.49	57.71	0.34	4.33
Hemi cellulose	162	23.73	14.61	38.82	0.33	4.23
Cellulose	162	35.97	28.68	46.16	0.2	2.61
Lignin	162	7.92	5.02	12.85	0.16	2.02
Protein	162	3.95	2.27	5.86	0.07	0.83
NBDMD	162	51.65	35	64.4	0.76	6.42

Table 5. Macro and micro mineral status of rice straw-State wise

State	Ca (%)	P (%)	Mg (%)	Cu (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)
Bihar	0.88	0.03	0.07	6.5	12.46	122.85	247.68
Chhattisgarh	0.6	0.08	0.07	4.88	20.69	132.91	203.78
Gujarat	0.49	0.12	0.07	5.39	22.68	134.25	159.67
Haryana	0.53	0.12	0.06	5.16	21.21	133.65	240.52
Jharkhand	0.61	0.15	0.06	6.59	28.83	133.45	252.1
Tamil Nadu	0.71	0.03	0.09	6.72	17.48	99.53	225.91
Uttar Pradesh	0.6	0.12	0.07	5.38	15.91	211.15	167.57
Uttarakhand	0.56	0.22	0.07	5.38	25.11	79.93	119.31
West Bengal	0.82	0.03	0.1	7.78	20.24	115.22	261.52

also recorded significant differences (P<0.05) for whole plant DMD values from different varieties in the order of: early maturing highest, the medium maturing higher and the late maturing lowest. However, there were no significant differences between CPD values of whole plant.The high levels of cell wall constituents were inversely related to the straw nutritional value, similar to that observed by Agbagla *et al.* (2001).Saebarinoto *et al.* (1993) also showed higher *in vivo* digestibilities and intake of the dry season straws, concomitant with a lower lignin and silica, but higher hemicellulose contents. The higher quality of stem compared to the leaf is a characteristic of rice straw (Vadiveloo, 1995) and higher quality of straw could be obtained from modem, semi-dwarf varieties because of their low leaf proportions.

Lignin located between the cellulose microfibrils is regarded as the most abundant natural aromatic organic polymer that plays a role in resisting compressing forces, and also inhibiting the rate and degree of microbial degradation (Iiyama *et al.,*1990). Lignin forms the complex with plant carbohydrate which remains un-dissociated under anaerobic environment of rumen (Sarnklong *et al.,*2010) as lignin degrading enzyme system does not exist in anaerobic environment.

CONCLUSIONS

Traditionally, straw production in the country is estimated by multiplying grain yield with a constant factor of straw to grain ratio. These estimates may require the precision due to variability in straw grain ratios. Results from this study demonstrate that application of prediction models based on region specific straw grain ratios would provide considerably better and precise estimates of straw yield. Chemical composition and digestibility of straw varied greatly among paddy cultivars/ varieties. This variability

Table 6.Variability in macro (% on DM basis) and micro (ppm) nutrient in straw of rice cultivars collected from different locations

Macro and Micro nutrients	Mean	Minimum	Maximum	SEM	SD
Phosphorus	0.12	0.024	0.245	0.008	0.058
Calcium	0.612	0.44	0.977	0.017	0.115
Magnesium	0.068	0.054	0.108	0.001	0.007
Copper	5.853	2.266	9.956	0.246	1.707
Zinc	22.102	8.498	40.976	1.081	7.493
Iron	215.077	105.784	611.838	14.398	99.75
Manganese	143.53	36.407	285.175	8.679	60.13

Table 7. Correlation among chemical constituents and DM degradabilityof paddy straw

Attribute	ADF	Lignin	Protein	NBDMD
Protein	-0.02	-0.26**	1	0.64**
NDMD	-0.40**	-0.59**	0.64**	1
ADF	1	0.1	-0.02	-0.40**
Lignin	0.1	1	-0.26**	-0.59**

*,**Correlation is significant at the level P<0.01 and P<0.05, respectively; n=162

presumably could be exploited to improve the nutritional value of the straw of future varieties. The straw crude protein and lignin contents are directly related with DM digestion. Therefore, the variation in nutritional parameters among the paddy cultivars/varieties needs to be exploited by the plant breeders.

ACKNOWLEDGEMENTS

Authors are thankful to Director, ICAR-IGFRI, Jhansi for providing necessary facilities. Assistance provided in sample collection work by the State Agricultural Universities and ICAR Institutes is also thankfully acknowledged.

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Received on 16-01-2019 and accepted on 06-05-2019

Indian J. Anim. Nutr. 2019. 36 (2): 173-178
doi: 10.5958/2231-6744.2019.00029.X

Indian Journal of Animal Nutrition

Effect of Organic and Inorganic Nutrient Sources on Yield and Quality of Fodder Cowpea [*Vigna unguiculata* (L.) Walp.]

Susanta Dutta*, Magan Singh[1], Rajesh Kumar Meena[1], Nirmalendu Basak[2], Goutam Mondal[3] and Phool Singh Hindoriya[1]

Agronomy Section, ICAR- National Dairy Research Institute, Karnal-132001, Haryana, India

ABSTRACT

A field experiment was conducted to ascertain the effect of organic and inorganic nutrient sources on yield and quality of fodder cowpea [*Vigna unguiculata* (L.) Walp.] during *kharif,* 2017 at Research Farm of Agronomy Section, ICAR- National Dairy Research Institute, Karnal. The experiment was laid out in Randomized Block Design with twelve nutrient combinations and replicated thrice. Nitrogen, phosphorus, potassium was applied in the form of urea, SSP and MOP, respectively and four different biofertilizers were used viz. rhizobium, phosphate solubilizing bacteria (PSB), potassium solubilizing bacteria (KSB) and zinc solubilizing bacteria (ZnSB). Application of RDF (N,P,K) along with biofertilizers (Rhizobium, Phosphorus Solubilizer Bacteria, Potassium Solubilizer Bacteria and Zinc Solubilizer Bacteria) Treatment [T_6] gave significantly (P<0.05) higher green fodder yield (334.5 q ha^{-1}), Dry matter content (17.80%) and dry matter yield (59.5 q ha^{-1}). Application of 2/3rd RDF along with biofertilizers (Rhizobium, PSB, KSB and ZnSB), [T_7] significantly (P=0.05) enhanced the quality parameters of fodder cowpea like crude protein (18.30 %), ether extract (3.48%) and total ash content (8.82%) while insoluble crude protein (NDICP and ADICP), organic matter and fiber fractions (NDF, ADF, ADL) were significantly (P<0.05) lowered. However, lignin content was comparable among the treatments. Therefore, it is concluded that reduction of one third RDF along with additional biofertilizers gave more improved quality fodder than rest of the treatments.

Keywords: Biofertilizers, Chemical composition, Fodder cowpea, Nutrient sources, Yields

INTRODUCTION

India has the largest livestock population of 512.05 million heads which is about 15 per cent of the world's livestock. India accounts for 57 per cent of world's buffaloes, 14 per cent of the world's cattle, 15 per cent of the world's goats and 5 per cent of world's sheep population (Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture. GOI, 2012). India faces an acute shortage of green fodder. To overcome this scarcity, dairy farmers' increases the use of costly concentrate feeds which ultimately increase the cost of production. Inadequate availability of forages both quantitatively and qualitatively had adversely affected the growth, health, reproduction and production potential of animals. Thus, improved productivity and qualitative fodder production are important issues to the farmers. Cowpea can grow as a sole and mixed crop with kharif cereals that may contribute to fulfillment of the nutrition requirement of the livestock by providing high protein supplement. Cowpea is the most important kharif leguminous fodder which has 15-18% protein and 18-22% crude fiber in their vegetative parts i.e. used as green fodder for the livestock.

Cowpea is one of the important kharif leguminous crop grown in India and is used for grain, fodder, green manuring purpose. The crop gives such a heavy vegetative growth and covers the ground so well that it checks the soil erosion in problematic areas and can later be ploughed in as a green manure. However, cowpea being a leguminous crop, it is a soil remunerative crop due to its atmospheric nitrogen fixing capacity by nodule formation. Because of that it requires minimum fertilization especially nitrogen as a starter dose for starting the nodulation process. However, yield potential of cowpea can be exploited by the application of adequate amount of nutrients required by the legumes. Next to nitrogen, phosphorus is also important plant nutrient which is needed by the leguminous crop for rapid and healthy root development. Micro nutrient like zinc is deficient in most part of India

[1]Agronomy Section, ICAR- National Dairy Research Institute. Karnal, Haryana-132001; [2]Soil Science Division, ICAR- Central Soil Science Research Institute; [3]Animal Nutrition Division, ICAR- National Dairy Research Institute; *Corresponding email: susantadutta19@gmail.com

specifically western region (Singh *et al*., 2007). Some investigators reported that seed inoculation with nitrogen fixer like rhizobium could improve the growth, yield and yield attributes of legume crops (Saleh *et al*., 2000; El-Habbasha *et al*., 2007). They further reported that integration of bacterial inoculation (PGPR) with inorganic fertilizers improved the yield as well as chemical traits of the produce. Other than these, most easily available organic manure like farm yard manure (FYM) also plays a greater role in fodder production as a supplemental source with inorganic fertilizers. An appropriate fertilizer management schedule is of paramount importance to ensure maximum yield and quality of fodder cowpea. Hence, this investigation was undertaken to study the effect of different nutrient sources designed in RBD to assess the yield and quality of the fodder cowpea.

MATERIALS AND METHODS

This experiment was conducted in kharif season of 2017 at Research Farm of Agronomy Section, ICAR-National Dairy Research Institute, Karnal, located in north western zone of Haryana state. This region comes under trans-gangetic agro climatic zone and climate was subtropical with extreme temperature variation. This zone receives rainfall from both southwest and northeast monsoons and the mean annual rainfall is about 707 mm of which major portion (about 574 mm) is received during the monsoon season (July to September) and rest during winter and spring seasons. The soil of this experimental field was clay loam in nature and the fertility was described in neutral pH (7.1), medium in organic carbon (0.61%), low in available N (175.6 kg ha^{-1}), medium in available P (20.8 kg ha^{-1}), medium in available K (212.6 kg ha^{-1}) and low in Zn concentration (0.432 ppm). The experiment was laid out in Randomized Block Design with twelve nutrient combinations and replicated thrice with gross plot size of 6.5 m × 5.5 m and net plot size of 6 m × 5 m. Sowing was done in leveled plots at a row spacing of 30 cm. Forty kg/ha seed rate of cowpea variety C-152 was used and sown on 18th July, 2017 manually in furrow and covered. Fodder cowpea variety (C-152) taken as a test crop, Nitrogen, phosphorus and potassium was applied in the form of urea, SSP and MOP, respectively. Four different biofertilizers were used *viz.* rhizobium, phosphate solubilizing bacteria (PSB), potassium solubilizing bacteria (KSB) and zinc solubilizing bacteria (ZnSB). These biofertilizers were procured from Division of Microbiology, ICAR- Indian Agricultural Research Institute, New Delhi. The twelve treatments are: (Control ($N_0P_0K_0$) [T_1]; RDF ($N_{20}P_{60}K_{40}$) [T_2]; RDF+PSB [T_3]; RDF+KSB [T_4]; RDF+ZnSB [T_5]; RDF+Rhizobium+PSB+KSB+ZnSB [T_6]; 2/3rd RDF+Rhizobium+PSB+KSB+ZnSB [T_7]; 15 kg N+60 kg P_2O_5+40 kg K_2O ha^{-1}+Rhizobium [T_8]; 10 kg N+60 kg P_2O_5+40 kg K_2O ha^{-1} +Rhizobium [T_9]; 60 kg P_2O_5+40 kg K_2O ha^{-1}+Rhizobium [T_{10}]; 5 t ha^{-1} FYM+ Rhizobium+PSB+KSB+ZnSB [T_{11}]; and 10 t ha^{-1} FYM [T_{12}]). Rhizobium inoculation was used @ 200 g for 10 kg of seed. Prepared the slurry of required quantity of inoculant in sufficient water (generally 400 ml of water for 200 g inoculant) and boil 50 g of gur in one litre of water and cooled it. Finally, mixed the seeds with slurry thoroughly and sown in the field within 24 hours. The dose and procedure followed was same for PSB inoculation with seed as per recommendation given by Central Research Institute of Dry land Agriculture (CRIDA). For KSB (potassium solubilizer bacteria) and ZnSB (zinc solubilizer bacteria) inoculation, diluted 50 ml of formulation with 1 liter of water and applied on seeds required for one acre of field. After harvesting of fodder crop, fresh fodder yield was recorded and samples were taken for quality analysis like dry matter content, proximate principles (AOAC, 2005), cell wall constituents (Van Soest *et al*., 1991) and protein fraction (Licitra *et al.,* 1996) of fodder cowpea. Data obtained were subjected to analysis of variance (ANOVA) following procedures for randomized block design (Gomez and Gomez, 1984). Treatment means were separated by Duncan's multiple range test and were considered significant at $P<0.05$.

RESULTS AND DISCUSSION

Green fodder yield was significantly influenced by different nutrient sources as shown in Fig.1. Maximum green fodder yield was obtained with treatment [T_6] (334.5 q ha^{-1}) followed by [T_7] (331.5 q

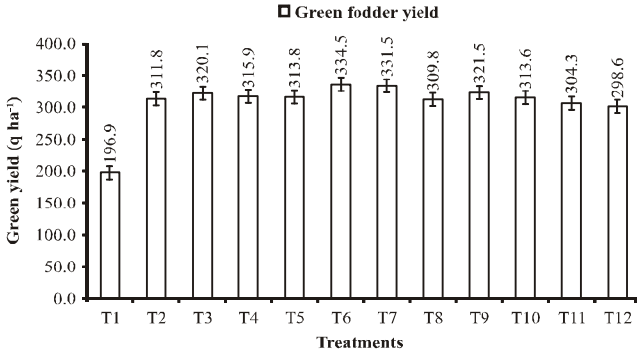

Fig 1. Effect of organic and inorganic sources of nutrients application on green fodder yield

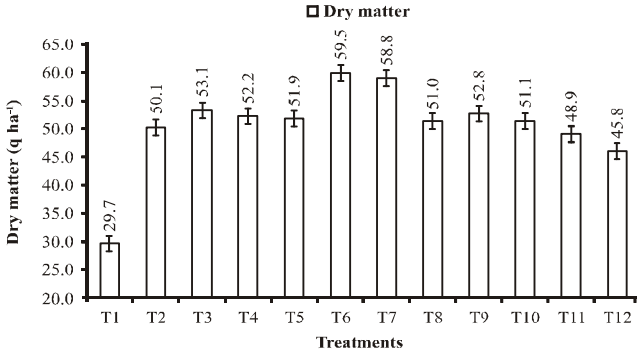

Fig 2. Effect of organic and inorganic sources of nutrients application on DM yield

ha^{-1}). All the treatments differed significantly (P<0.05) as compared to control [T_1] (196.9 q ha^{-1}). The increased supply of nitrogen and its higher uptake plants might have stimulated the rate of various physiological processes in plant that led to increased growth and yield parameters. These results are in close conformity with the findings of Patel *et al.* (2003) and Singh *et al.* (2007).

Phosphorus plays an important role in nitrogen-fixation in legumes and in energy metabolism during early formation of roots and their proliferation. Increased in yield parameters could be ascribed due to the overall improvement in plant growth and vigour with Rhizobium inoculation. The beneficial effect of these inoculations on yield attributes were seen due to better availability of nutrients and their translocation, which was reflected in terms of increased green fodder yield of cowpea.

DM yield as influenced by different nutrient sources are shown in Fig.2. Highest dry matter yield was recorded in treatment [T_6] (59.5 q ha^{-1}), followed by [T_7] (58.8 q ha^{-1}). All the treatments differed significantly (P<0.05) as compared to control [T_1]. Dry matter yield is influenced by nutrient accumulation in plant. Use of rhizobium and solubilizer might have facilitated the accumulation of the major nutrients. Significantly higher dry matter percentage was observed in treatment [T_6] (17.80 %) as compared to control [T_1] (15.07 %), followed by [T_7] (17.73 %). Higher dry matter accumulation in these groups could be attributed

Table 1. Effect of organic and inorganic sources of nutrients application on DM, Ash, OM, CP (%) content and CP yield (q ha^{-1})

Treatments	DM	Ash	OM	CP	CP yield
T_1	15.07^{d}	7.87^{b}	92.13^{a}	16.47^{h}	4.89^{g}
T_2	16.08^{c}	8.65^{a}	91.35^{b}	17.50^{e}	8.78^{d}
T_3	16.58^{b}	8.76^{a}	91.24^{b}	18.10^{bc}	9.61^{b}
T_4	16.51^{b}	8.74^{a}	91.26^{b}	18.09^{bc}	9.43^{b}
T_5	16.54^{b}	8.72^{a}	91.28^{b}	17.99^{cd}	9.33^{bc}
T_6	17.80^{a}	8.79^{a}	91.21^{b}	18.11^{b}	10.64^{a}
T_7	17.73^{a}	8.82^{a}	91.18^{b}	18.30^{a}	10.89^{a}
T_8	16.47^{b}	8.63^{a}	91.37^{b}	17.44^{ef}	8.90^{cd}
T_9	16.43^{bc}	8.60^{a}	91.40^{b}	17.37^{f}	9.17^{bcd}
T_{10}	16.28^{bc}	8.67^{a}	91.33^{b}	17.96^{d}	9.17^{bcd}
T_{11}	16.06^{c}	8.44^{b}	91.56^{a}	16.85^{g}	8.24^{e}
T_{12}	15.34^{d}	7.96^{b}	92.04^{a}	16.55^{h}	7.59^{f}
SEm ±	0.12	0.18	0.18	0.07	0.16

^{a,b,c} values with different subscript within a column represent significant difference

to increasing availability of phosphorus and rhizobium inoculation in these treatment (Bohra *et al*., 1990).

Ash is the inorganic content after removing the water and organic matter of the sample, which provide a measure of total mineral in the sample. Ash content of the fodder sample was significantly higher in all treatments except [T_{11} and T_{12}] over the unfertilized plot *i.e.* control (Table 1) which could be attributed to nutrient assimilation by plant grown on fertilized plots. Higher organic matter (92.13 %) of the fodder sample was found in control plot as listed in Table-1 A declining trend in OM content was observed with increasing application of inorganic fertilizer.

Data pertaining to CP (%) and CP yield of cowpea are presented in Table 1. Both the parameters were influenced by nutrient sources. Significantly higher CP content of fodder cowpea was obtained in treatment T_7 followed by T_6 (18.30 and 18.11%, respectively) over control (T_1, 16.47%). However, other treatments also significantly differed from the control except [T_{12}]. On the basis of CP (%), DM and CP yield (q ha^{-1}) also varied accordingly and significantly higher CP yield was calculated in treatment [T_7] followed by [T_6] (10.89 and 10.64 q ha^{-1}, respectively) in comparison to control (4.89 q ha^{-1}). Increased in protein by seed inoculation may be attributed to increase availability of nitrogen and phosphorus because of that nitrogen is the main component of the protein fraction (Magani and Kuchinda, 2009).

The data pertaining to ether extract and total carbohydrate contents are furnished in Table2. Content of Ether extract and Total carbohydrate were higher in treatment group as compared to control group, best response was obtained in T_7 followed by T_6. Lower ether extract and total carbohydrate in samples collected from control (T_1) could be attributed to fact that the soil of the studies area was deficient in Zn. Zn deficiency is known to induce stress in crops (Cakmak, 2000). Both the treatment T_6 and T_7 contained Zn solublising bacteria. As a result, availability and uptake of Zn was increased (Dutta, 2018). This might have relieved that plants from stress and improved metabolism and synthetic activity, causing an improvement in ether extract and total carbohydrate content. Further if we make a comparison of T_6 and T_7 with T_4, even though all these three groups contained Zn solubilizing bacteria response obtained in T_4 was lower. Although, T_4 contained Zn solubilising bacteria, but did not contained

Table 2. Effect of organic and inorganic sources of nutrients application on EE, T-CHO, NDF, ADF, ADL and hemicellulose content (%)

Treatments	EE	T-CHO	NDF	ADF	Hemi cellulose	ADL
T_1	2.82^{e}	74.74^{a}	41.66^{a}	31.07^{a}	10.59^{a}	8.54^{a}
T_2	3.36^{b}	71.09^{cd}	39.63^{bcd}	29.84^{b}	9.79^{c}	8.24^{a}
T_3	3.09^{d}	70.65^{def}	39.53^{cd}	29.77^{b}	9.75^{c}	8.24^{a}
T_4	3.19^{c}	70.59^{def}	39.59^{bcd}	29.81^{b}	9.78^{c}	8.26^{a}
T_5	3.23^{c}	70.66^{def}	39.55^{cd}	29.79^{b}	9.77^{c}	8.19^{a}
T_6	3.44^{a}	70.26^{ef}	39.50^{cd}	29.75^{b}	9.75^{c}	7.98^{a}
T_7	3.48^{a}	70.00^{f}	39.47^{d}	29.75^{b}	9.71^{c}	8.00^{a}
T_8	3.36^{b}	71.17^{cd}	39.69^{bcd}	29.87^{b}	9.82^{c}	8.30^{a}
T_9	3.19^{c}	71.44^{c}	39.77^{bcd}	29.88^{b}	9.89^{bc}	8.33^{a}
T_{10}	3.10^{d}	70.87^{cde}	39.50^{d}	29.73^{b}	9.77^{c}	8.12^{a}
T_{11}	2.86^{e}	72.77^{b}	40.25^{bc}	30.03^{b}	10.20^{abc}	8.36^{a}
T_{12}	2.86^{e}	74.10^{a}	40.51^{b}	30.13^{b}	10.39^{ab}	8.50^{a}
SEm ±	0.04	0.22	0.16	0.16	0.17	0.17^{a}

^{a,b,c} values with different subscript within a column represent significant difference

Table 3. Effect of organic and inorganic sources of nutrients application on NDICP and ADICP content (%)

Treatments	NDICP		ADICP	
	DM	CP	DM	CP
T_1	7.69[a]	50.85[a]	2.75[a]	18.18[a]
T_2	7.39[ab]	42.21[c]	2.56[ab]	14.64[cde]
T_3	7.20[bc]	39.79[cde]	2.46[b]	13.58[ef]
T_4	7.25[abc]	40.06[cde]	2.52[ab]	13.94[def]
T_5	7.39[ab]	41.07[cd]	2.60[ab]	14.48[cde]
T_6	7.04[bc]	38.89[de]	2.46[b]	13.58[ef]
T_7	6.84[c]	37.40[e]	2.40[b]	13.10[f]
T_8	7.33[abc]	42.01[c]	2.58[ab]	14.82[cd]
T_9	7.39[ab]	42.52[c]	2.65[ab]	15.23[c]
T_{10}	7.27[abc]	40.47[cd]	2.56[ab]	14.27[cde]
T_{11}	7.50[ab]	45.35[b]	2.69[ab]	16.26[b]
T_{12}	7.59[a]	48.55[a]	2.73[a]	17.45[a]
SEm ±	0.15	0.85	0.08	0.31

[a,b,c] values with different subscript within a column represent significant difference

rhizobium. Nitrogen uptake was lower in T_4 as compared to T_6 and T_7. Nitrogen is required for synthesis of amino acid and protein. Inadequate supply of nitrogen will have adverse impact on synthetic activity. Likewise, P helps in root nodule formation as well as play key role in energy transfer during different metabolic activities. Thus, a combination of rhizobium, P, K and Zn solubilizing bacteria along with RDF are the best nutrient strategy for fodder cowpea.

The data on NDF (%) content of cowpea fodder as influenced by different nutrient sources are presented in Table-2. Significantly lower NDF value was found in treatment [T_7] (39.47 %) over the control (41.66 %). Significantly lower ADF content was obtained in treatment [T_7] (29.75 %) and [T_6] (29.75%) with comparison to control (31.07 %). Lower fibre content in T_7 corroborates well with higher CP, EE and total carbohydrate content in that group. Content of cell wall fraction is known to inversely related with content of soluble fractions, particularly CP. Lower content of cell wall fractions in T_7 was thus expected and could be considered as an improvement in fodder quality due to provision of nutrients through rhizobium, P, K and Zn solubilizing bacteria.

Data pertaining to NDICP and ADICP content (%) of cowpea as influenced by organic and inorganic sources of nutrients are tabulated in Table 3. Significantly lower value of NDICP and ADICP were obtained in treatment T_7 as compared to control. Lower fibre bound CP in T_7 could be attributed to lower cell wall content in that group. It further implies that CP of cowpea fodder grown under nutrient management system of T_7 would be of superior quality as it would supply more available protein to ruminant animal as compared to those grown under other nutrient management system. As discussed before superiority of T_7 over other treatment group could be due to the fact that it contained a combination rhizobium, P, K and Zn solubilizing bacteria along with RDF. An appropriate supply of N. P, K and Zn is of paramount importance for quality production of fodder cowpea. Amongst all the treatments, T_7 supplied these nutrients for optimum production of quality fodder cowpea.

CONCLUSIONS

Based on the present investigation, it is concluded that reduction of one third RDF along with additional biofertilizers improved yield and quality of fodder cowpea.

ACKNOWLEDGEMENTS

The authors are grateful to Director, ICAR-NDRI, Karnal, Haryana, India for providing required facilities and financial assistance for carrying out this study.

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Received on 29-10-2018 and accepted on 01-03-2019

Indian J. Anim. Nutr. 2019. 36 (2): 179-186
doi: 10.5958/2231-6744.2019.00030.6

Indian Journal of Animal Nutrition

Productivity and Quality of Fodder Oats (*Avena sativa* L.) as influenced by Sowing Time, Cutting Schedules and Nitrogen Levels

S.S. Kadam[1], N.S. Solanki[2], Mohd. Arif[*3], L.N. Dashora[2], S.L. Mundra[2] and B. Upadhyay[4]
Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur-313 001, Rajasthan, India

ABSTRACT

A field experiment was conducted at Agronomy Farm, Rajasthan College of Agriculture, Udaipur, (Rajasthan) during *rabi* seasons of 2016-17 and 2017-18 to study the effect of sowing time (25th October and 25th November), cutting schedules (cut at 50 DAS, cut at 60 DAS and cut at 70 DAS) and nitrogen levels (80, 100 and 120 kg ha^{-1}) on productivity and quality of fodder oats. It was revealed that early sown crop on 25th October recorded significantly higher green (36.4 t ha^{-1}) and dry (8.0 t ha^{-1}) fodder yield as well as green (611 kg ha^{-1} day^{-1}) and dry (134 kg ha^{-1} day^{-1}) fodder production efficiency and quality parameters *viz.* ether extract (2.52%). Among different cutting schedules, cutting at 70 DAS recorded significantly higher green (37.8 t ha^{-1}) and dry (8.3 t ha^{-1}) fodder yield. However, cut at 50 DAS proved significantly better in terms of green (628.7kg ha^{-1} day^{-1}) and dry (137.0 kg ha^{-1} day^{-1}) fodder production efficiency as well as quality parameters *viz.* crude protein (12.3%) and ether extract (2.56%). Application of 120kg N ha^{-1} gave significantly higher green (36.5 t ha^{-1}), dry (8.0 t ha^{-1}) fodderyield and green (613.5 t ha^{-1}), dry (34.4 t ha^{-1}) fodder production efficiency and quality parameters *viz.* crude protein (12.1 %) and ether extract (2.53 %).It is concluded that among sowing times 25th October, among cutting schedule 50 DAS and among nitrogen levels 120 kg N ha^{-1} is the best treatment for recoding maximum value of green and dry fodder production efficiency and ether extract.

Keywords: Cutting and nitrogen, Oats, Productivity, Quality, Sowing

INTRODUCTION

In India the livestock is an integral component of agriculture economy which contributes about 4.11 % to total GDP and posses 15% of world's livestock population of 512.05 million constituting 37.3% cattle, 21.2% buffaloes, 12.7% sheep and 26.4% goats (DAHD & F 2017-18). The success of animal husbandry and dairy farming largely depends on regular supply of good quality fodder in sufficient quantities. Unfortunately, there is acute shortage of green as well as dry fodder in tune of 35.6 and 11.0 per cent, respectively (IGFRI Vision 2050) due to less acreage of green fodder crops (4.9 per cent) and more emphasis on food grain production (Kumar *et al.,* 2018; Pandey and Roy, 2011) that drastically affects the productivity of animals in comparison with other countries.

The mismatch in demand and supply of fodders as per projected scenario requires urgent attention to develop suitable strategies to bridge this gap. Oats (*Avena sativa* L.), is the most important *rabi* season crops grown for animal food under irrigated conditions of northern and north-western regions of India because of its excellent growth habit, quick regeneration capacity, better palatability with more protein and minerals content. Besides, it is also used for making silage for animals (Chakraborty *et al.,* 2016; Kumari *et al.,* 2014). Productivity and quality of oats depend upon various inputs like sowing time and cutting schedules besides fertilizer application. It has been proved that timely sowing (Shekara and Lohithaswa, 2012) and cutting of oats (Demetrio *et al.,* 2012) enhanced forage productivity as well as quality. Nitrogenous fertilizer is also the key factor which influences both yield and quality oat forage (Singh and Dubey, 2007; Subrahmanya *et al.,* 2017; and Yadav *et al.,* 2017). Hence, the present investigation was undertaken to ascertain the productivity and quality of fodder oats as influenced by sowing time, cutting schedules and nitrogen levels.

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Maharana

[1]Fodder Development Officer, BVC, Mumbai and Ph.D. Scholar, RCA, MPUAT, Udaipur-313 001, Rajasthan, India; [2]Professor Agronomyand [4]Professor Agril. Statistics RCA, MPUAT, Udaipur-313 001, Rajasthan, India; [3*]Scientist ICAR-Central Institute for Research on Goats, Makhdoom; [*]Corresponding author (E-mail: arifkhan.ag782@gmail.com)

Pratap University of Agriculture and Technology, Udaipur, (Rajasthan) during two consecutive *rabi* seasons of 2016-17 and 2017-18. The soil of experimental field was clay loam in texture that was low in available nitrogen and organic carbon, medium in available phosphorous and high in potassium status with slightly alkaline in reaction. The treatments consisting two sowing dates (25th October and 25th November), four cutting schedules (no cut, cut at 50 DAS, cut at 60 DAS and cut at 70 DAS) in main plots and three levels of nitrogen (80, 100 and 120 kg ha^{-1}) in subplots were laid out in Split Plot Design with three replications in plot size of 5.0 × 3.0 m^2. Dual purpose oats variety UPO-212 was sown by drilling method at 25 cm row spacing @ 100 kg ha^{-1}. Among fertilizer dose,1/3rd nitrogen and full dose of phosphorous and potassium (each 40 hg ha^{-1}) was supplied as basal dose through urea, DAP and MOP fertilizers. 1/3rd N as per treatment applied after first irrigation and remaining 1/3rd N was given after cutting treatment and for no cut treatment applied at 60 DAS through urea. Irrigations and spraying of 2,4-D weedicide were carried out as per recommendations. Cutting for green fodder was taken at 10 cm above ground level from net plot, then weighed and converted into tonnes ha^{-1} to obtain green fodder yield. After harvesting green fodder, the crop was left for grain purpose. Simultaneously, a random sample of 500 g was taken from each net plot, chopped well and first dried in sun and then oven dried at 65-70°C till constant weight. On the basis of these samples, the green fodder yields were converted into dry fodder yields and were expressed as t ha^{-1}. Green as well as dry fodder production efficiency day^{-1} was calculated by dividing respective green and dry fodder yield by number of days for cutting and expressed in kg ha day^{-1}. The oven dried sample of oats were then ground and used for proximate analysis as per AOAC (1995).

RESULTS AND DISCUSSION

Sowing time had significant influence on green and dry fodder yield of oats during both *rabi* seasons and in pooled values (Table 1). It was observed that significantly higher green (36.4 t ha^{-1}) and dry (8.0 t ha^{-1}) fodder yield could be obtained with crop sown on 25th October as compared to 25th November sown crop (32.9 and 7.1 t ha^{-1}, respectively). The corresponding increment in green and dry fodder yield was in tune of 10.5 and 11.9 per cent, respectively. Further, significantly higher green (611.0 kg ha^{-1} day^{-1}) and dry (134.0 kg ha^{-1} day^{-1}) fodder production efficiency was registered with early sown crop on 25th October as compared to late sown crop on 25th November (552.7 and 120.4 kg ha^{-1} day^{-1}). Delay in sowing decreased the green and dry fodder yield, and fodder production efficiency of oats. The higher fodder yield as well as fodder production efficiency in early sown crop might be due to favourable climatic situations that might have led into luxuriant vegetative growth in the forms of plant height, number of tillers, dry matter accumulation and leaf stem ratio. Our findings are in conformity with Jehangir *et al.* (2012); Kumar (2012); Shekara and Lohithaswa (2012); Dar *et al.* (2014) and Sheoran *et al.* (2017).

The results showed that green and dry fodder yield of oats were remarkably influenced by different cutting schedules during both *rabi* seasons. Cut at 70 DAS gave significantly higher green fodder yield (37.8 t ha^{-1}) over cut at 60 DAS (34.6 t ha^{-1}) and cut at 50 DAS (31.4 t ha^{-1}) by 9.3 and 20.3 per cent, respectively. Similarly, cut at 70 DAS recorded significantly higher dry fodder yield (8.3 t ha^{-1}) over cut at 60 DAS (7.6 t ha^{-1}) and cut at 50 DAS (6.9 t ha^{-1}) by 9.0 and 20.6 per cent, respectively (Table-1). Increment in green and dry fodder yield because of delayed cutting might be due to longer vegetative growth period availed that increased growth as well as yield attributes and accumulated more photosynthates and dry matter, resulting in higher forage production of oats as compared to earlier cutting.The higher green and dry fodder yield may be due to higher plant height (r = 0.968 and r =0.908), number of tillers (r = 0.913 and r = 0.826), dry matter resulting in (r = 0.985 and r = 0.950) and leaf stem ratio (r = 0.881 and r = 0.796), respectively at this stage.Other reports (Hussain *et al.* 2004; Hedayetullah and Barik,

Table 1. Effect of sowing time, cutting schedules and nitrogen levels on green, dry fodder yield and fodder production efficiency of oats

Treatments	Green fodder yield (t ha^{-1})			Dry fodder yield (t ha^{-1})			Green fodder production efficiency (kg ha^{-1} day^{-1})			Dry fodder production efficiency (kg ha^{-1} day^{-1})		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Sowing time												
D_1 - 25th October	36.1	36.6	36.4	7.9	8.1	8.0	607.1	615.0	611.0	132.4	135.7	134.0
D_2 - 25th November	32.7	33.1	32.9	7.0	7.2	7.1	548.7	556.6	552.7	118.5	122.3	120.4
SEm±	0.67	0.67	0.47	0.15	0.17	0.11	6.87	7.92	5.24	2.69	1.51	1.54
CD at 5 %	2.12	2.10	1.40	0.48	0.54	0.34	21.64	24.94	15.46	8.47	4.76	4.55
Cutting schedules												
C_1 - Cut at 50 DAS	31.2	31.7	31.4	6.8	7.0	6.9	623.9	633.5	628.7	135.0	139.0	137.0
C_2 - Cut at 60 DAS	34.4	34.8	34.6	7.5	7.7	7.6	572.8	580.3	576.6	124.6	128.0	126.3
C_3 - Cut at 70 DAS	37.6	38.1	37.8	8.2	8.4	8.3	537.0	543.5	540.3	116.5	120.2	118.4
SEm±	0.83	0.81	0.58	0.19	0.21	0.14	8.41	9.70	6.42	3.29	1.85	1.89
CD at 5 %	2.60	2.57	1.71	0.59	0.66	0.41	26.50	30.55	18.93	10.37	5.83	5.57
Nitrogen levels												
N_1 - 80 kg ha^{-1}	32.2	32.7	32.5	7.0	7.2	7.1	541.2	549.0	545.1	117.9	121.3	119.6
N_2 - 100 kg ha^{-1}	34.7	35.2	34.9	7.5	7.7	7.6	583.0	591.0	587.0	125.7	129.8	127.7
N_3 - 120 kg ha^{-1}	36.2	36.7	36.5	7.9	8.1	8.0	609.6	617.3	613.5	132.7	136.1	134.4
SEm±	0.46	0.33	0.28	0.13	0.19	0.12	5.85	5.39	3.98	2.08	1.28	1.22
CD at 5%	1.33	0.97	0.79	0.38	0.57	0.33	17.08	15.74	11.17	6.08	3.72	3.43

2012; Patel *et al.* 2013; Malik, 2014; Kumar *et al.* 2017) also reported that cutting management had remarkable effect on green and dry fodder yield of oats. Further; it was also observed (Table-1) that green and dry fodder production efficiency ha^{-1} day^{-1} of oats was significantly influenced by different cutting schedules. It was found that cut at 50 DAS registered higher green fodder production efficiency (628.7 kg ha^{-1} day^{-1}) over cut at 60 DAS and cut at 70 DAS by 9.0 and 16.4 per cent, respectively. Similarly, cut at 50 DAS obtained significantly higher dry fodder production efficiency (137.0 kg ha^{-1} day^{-1}) over cut at 60 DAS and cut at 70 DAS by 8.5 and 15.8 per cent, respectively.The higher fodder production efficiency associated with early cutting might be due to less duration required for cutting. The fodder production efficiency is always inversely proportional to number of days required for harvesting. The green fodder production efficiency had negative correlation with plant height (r = - 0.897), number of tillers (r = - 0.812), dry matter accumulation (r = - 0.950) and leaf stem ratio (r = - 0.802) under different cutting schedules. Alipatra *et al.* (2013) also reported that fodder production efficiency was significantly influenced due to cutting management.

Dry fodder yield and fodder production efficiency day^{-1} of oats were remarkably influenced by various nitrogen levels during two *rabi* seasons and in pooled values. It was interpreted that application of 120 kg N ha^{-1} recorded maximum green fodder yield (36.5 t ha^{-1}) followed by 100 kg N ha^{-1} and 80 kg N ha^{-1} which was significantly higher by 4.4 and 12.3 per cent, respectively. Similarly, application of 120 kg N ha^{-1} gave significantly higher dry fodder yield (8.0 t ha^{-1}) over 100 kg N ha^{-1} and 80 kg N ha^{-1} by 5.5 and 12.5 per cent, respectively (Table-1). Further, application of 120 kg N ha^{-1} obtained significantly higher green fodder production efficiency (613.5 kg ha^{-1} day^{-1}) than 100 and 80 kg N ha^{-1} by 4.5 and 12.5 per cent, respectively and higher dry fodder production efficiency (134.4 kg ha^{-1} day^{-1}) by 5.2 and 12.4 per cent, respectively. The increment in green, dry fodder yield and production efficiency due to higher dose of nitrogen may be due to luxuriant vegetative growth achieved in form of plant height, number of tillers, dry matter accumulation and leaf stem ratio which enhanced the photosynthetic activities and hence forage production as well as production efficiency. Results coincide with the findings of Luikham *et al.* (2012); Malik (2014); AICRP-FCU, (2016); Ratan *et al.* (2016) and Kumar *et al.* (2017).

Sowing time had no significant influence with respect to crude protein content in fodder oats (Table 2). This might be due to non-significance of nitrogen content in fodder oats due to sowing time as nitrogen being main constituent that play important role in formation of amino acids as well as protein in plants. Similar findings were reported by Mutti (1995). Kumar (2012) also reported that sowing time had no significant influence on crude protein content during second cut of oats. Further, crude fibre and ether extract content in fodder oats were significantly affected due to sowing time during both *rabi* seasons. Oat crop sown on 25th October recorded significantly lower crude fibre (23.1 per cent) and higher ether extract (2.52 per cent) in comparison with crop sown on 25th November (24.0 and 2.34 per cent, respectively). The lower crude fibre associated with early sown crop might be due to more leaf stem ratio. Higher ether extract with early sown crop may be due to availability of favourable environments for rapid metabolic activities and better biomass production as compared to late sown crop. The results are in conformity with Kumar (2012); Dar *et al.* (2014) and Jehangir *et al.* (2017). As per data (Table 2) it is evident that significantly higher ash content (13.3 per cent) was noticed with 25th October sown crop in comparison with 25th November sown crop (12.5 per cent). The higher ash content due to early sown crop may be due to higher dry matter content as compared to delayed sown crop. Kumar (2012) and Jehangir *et al.* (2017) also reported similar findings. Nitrogen Free Extract (NFE) in fodder oats was not significantly influenced due to sowing time during both *rabi*

Table 2. Effect of sowing time, cutting schedules and nitrogen levels on crude protein, crude fibre, ether extract, ash and NFE content in fodder oats

Treatments	Crude protein (%)			Crude fibre (%)			Ether extract (%)			Ash content (%)			NFE(%)		
	20116	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Sowing time															
D_1 - 25th October	12.0	12.0	12.0	23.1	23.1	23.1	2.52	2.53	2.52	13.3	13.3	13.3	49.1	48.7	48.9
D_2 - 25th November	11.8	11.8	11.8	24.0	24.0	24.0	2.34	2.33	2.34	12.5	12.5	12.5	49.3	49.1	49.2
SEm±	0.09	0.07	0.06	0.10	0.09	0.07	0.02	0.01	0.01	0.05	0.05	0.04	0.18	0.17	0.12
CD at 5 %	NS	NS	NS	0.31	0.29	0.20	0.06	0.03	0.03	0.15	0.16	0.10	NS	NS	NS
Cutting schedules															
C_1 - Cut at 50 DAS	12.2	12.3	12.3	23.3	23.4	23.3	2.57	2.56	2.56	12.7	12.8	12.8	49.0	49.0	49.0
C_2 - Cut at 60 DAS	12.2	12.3	12.2	23.5	23.5	23.5	2.45	2.44	2.44	12.8	12.9	12.8	49.0	49.0	49.0
C_3 - Cut at 70 DAS	11.2	11.2	11.2	23.8	23.8	23.8	2.27	2.29	2.28	13.2	13.2	13.2	49.6	48.8	49.2
SEm±	0.11	0.09	0.07	0.12	0.11	0.08	0.02	0.01	0.01	0.06	0.06	0.04	0.21	0.21	0.15
CD at 5 %	0.36	0.29	0.21	0.39	0.35	0.23	0.08	0.04	0.04	0.19	0.20	0.13	NS	NS	NS
Nitrogen levels															
N_1 - 80 kg ha^{-1}	11.7	11.7	11.7	23.6	23.6	23.6	2.29	2.29	2.29	12.8	12.8	12.8	49.6	49.3	49.4
N_2 - 100 kg ha^{-1}	11.8	11.9	11.9	23.6	23.6	23.6	2.47	2.48	2.47	12.8	12.9	12.9	49.2	48.9	49.1
N_3 - 120 kg ha^{-1}	12.1	12.1	12.1	23.5	23.5	23.5	2.53	2.53	2.53	13.1	13.1	13.1	48.8	48.6	48.7
SEm±	0.08	0.06	0.05	0.12	0.11	0.08	0.02	0.01	0.01	0.05	0.06	0.04	0.16	0.20	0.13
CD at 5%	0.23	0.17	0.14	NS	NS	NS	0.05	0.03	0.03	0.16	0.18	0.11	0.46	0.60	0.36

NS - Non significant

seasons. Similar findings were reported by Kumar (2012).

The results (Table 2) indicate that crude protein, crude fibre, ether extract and ash content in fodder oats were significantly affected due to various cutting schedules during both the years and in pooled data. However, nitrogen free extract content was not influenced because of different cutting schedules. Cut at 50 DAS recorded significantly higher crude protein (12.3 per cent) and ether extract content (2.56 per cent) over cut at 70 DAS. However, cut at 70 DAS registered significantly higher ash (13.2 per cent) and crude fibre content (23.8 per cent) over rest of cutting schedules. Various cutting schedules did not affect Nitrogen Free extract of fodder oats. The higher crude protein content at early cutting might be due to more nitrogen content in fodder at this stage which is a main constituent that plays major role in synthesis of protein.The dilution effect where photosynthates get dissolved in higher biomass produced during later stage might have resulted in declined protein content due to delayed cutting. Results are in conformity with results of Hussain *et al.* (2004); Bhilare and Joshi (2007); Jehangir *et al.* (2012); Malik *et al.* (2015) and AICRP-FCU, (2016). Similarly, ether extract or crude fat declined due to delayed cutting might be due to plants were at late vegetative growth stage and ether extract get declined with advancement of cutting. Similar results was reported by Kumar (2012). Crude fibre content increases with maturity of crop and more fibrous nature of stem than that of leaf. These results are in conformity with the results of Hussain *et al.,* (2004); Jehangir *et al.* (2012) and Kumar (2012). The higher ash content at later stage of crop may be due to less moisture and more dry matter content. Similarly, Kumar (2012) reported that cutting management had significant influence on ash content.

Data (Table 2) demonstrate that different nitrogen levels caused significant variation in crude protein, ether extract, ash and nitrogen free extract content in fodder oats during both *rabi* seasons and also in pooled samples. Application of 120 kg N ha^{-1} registered more crude protein (12.1 per cent), ether extract (2.53 per cent) and ash content (13.1 per cent) which was significantly superior over 100 and 80 kg N ha^{-1}. Application of 80 kg N ha^{-1} recorded significantly higher nitrogen free extract (49.4 per cent) over 120 kg N ha^{-1} (48.7 per cent). The various nitrogen levels had no any significant influence on crude fibre content of fodder oats. The higher dose of nitrogen might have increased the protein content as nitrogen being the major constituent for synthesis of protein as well as amino acid. Patel *et al.* (2011and Sheoran *et al.* (2017) also reported that crude protein content in fodder oats was significantly influenced by nitrogen application. The increase in ether extract content because of high dose of nitrogen may be due to the fact that nitrogen accelerates the respiration process that converts the most of carbohydrate into crude fat. However, crude fibre content in fodder oats was not influenced by nitrogen levels during entire investigation period. The application of nitrogen might have failed to produce fibroid components such as lignin and cellulose in plants. The more ash content with high dose of nitrogen may be due to rapid respiration caused because of acceleration of meristemetic activities that converts carbohydrate into ash. Bhilare and Joshi (2007) also reported that ash content in fodder oats differed significantly due to nitrogen application.

CONCLUSIONS

Early sown (25th October) dual purpose oats recorded significantly higher values of green and dry fodder yield as well as fodder production efficiency. Further, cutting at 50 DAS recorded higher green and dry fodder production efficiency, and crude protein and ether extract content. Application of 120 kg N ha^{-1}resulted in higher green and dry fodder yield as well as fodder production efficiency, and crude protein, ether extract and ash content. Thus, it is concluded that among sowing times 25th October, among cutting schedule 50 DAS and among nitrogen levels 120 kg N ha^{-1} is the best treatment for recoding maximum value of green

and dry fodder production efficiency and ether extract content.

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Received on 29-04-2019 and accepted on 12-06-2019

Indian J. Anim. Nutr. 2019. 36 (2): 187-197
doi: 10.5958/2231-6744.2019.00031.8

Indian Journal of Animal Nutrition

Challenzyme Supplementation of High Expeller Copra Meal in Corn-animal Protein Diets for Broilers: Growth Performance, Nutrient Digestibility and Carcass Traits

Ashika Devi, Siaka Seriba Diarra* and Sandy Hoffman Mael
School of Agriculture and Food Technology, Alafua Samoa, University of the South Pacific, Samoa

ABSTRACT

A five-week experiment was conducted to investigate the effects of Challenzyme supplementation of expeller copra meal (ECM) fed in corn-animal protein-based diets on growth performance, nutrient digestibility, carcass and gut measurements of broilers. A total of 168, 9 days old Cobb 500 broilers were assigned to 8 diets consisting of 2 controls (with and without enzyme) and 6 other diets consisting 150, 300 and 450 g/kg ECM levels (with and without enzyme), were fed in three replicates of 6 birds each in a completely randomized design. Results showed significant interactions effects on growth parameters and fat digestibility. Feed intake and weight gain were reduced on 300 and 450 g/kg ECM diets ($P<0.05$). Fat digestibility was improved on control and 300 g/kg ECM diets with enzyme ($P<0.05$). Carcass measurements were not affected by dietary treatments ($P>0.05$). In the main effects, feed intake and weight gain were reduced and feed conversion ratio increased with increasing level of ECM above 150 g/kg ($P<0.05$). Enzyme supplementation improved crude fibre and fat digestibility of broilers ($P<0.05$). In conclusion, 300 g/kg dietary ECM with enzyme inclusion has no detrimental effects on growth of finishing broilers. More research into enzyme source and concentration above 300 g/kg ECM is recommended.

Keywords: Alternative protein sources, Broiler performance, Diet composition, Exogenous enzyme, Nutrient digestibility

INTRODUCTION

Exorbitant feed cost has directed research efforts into alternative feed resources for poultry feeding. Traditional protein sources such as soybean meal is expensive in the South Pacific region. Copra meal is readily available in the region and could be utilised to reduce feed cost. The crude protein content of ECM ranges from 150-250 g/kg (Devi and Diarra, 2017; Diarra *et al.,* 2018; Devi and Diarra, 2019). The lower essential amino acid profile, especially lysine and methionine (Sundu *et al.,* 2009; Devi and Diarra, 2017; Devi and Diarra, 2019) and high non-starch polysaccharides (NSP) contents (420-610 g/kg) (Knudsen, 1997; Devi and Diarra, 2017; Saittagaroon *et al.,* 1983 cited in Sundu *et al.,* 2012) are the major limitations to the efficient utilisation of ECM in poultry diets. Dietary recommendations range from 50-300 g/kg (Sundu *et al.,* 2006; Bastos *et al.,* 2007; Diarra *et al.,* 2014; Diarra *et al.,* 2015; Devi and Diarra, 2017). Several technologies including amino acid and enzyme supplementation (Sundu *et al.,* 2004; 2009; Diarra *et al.,* 2014), choice of dietary ingredients (Devi and Diarra, 2017) and feed processing (Sundu *et al.,* 2009) can improve the utilisation of ECM in poultry diets. Recently, Devi and Diarra (2017) observed that broilers could utilise 150 g/kg ECM fed in diets based on corn-animal proteins (fish meal and meat and bone meal) better than plant protein sources. This study investigated the effect of enzyme supplementation of ECM in corn-animal protein based diets. We hypothesized that:

i) Higher levels of ECM can be fed in corn-animal protein diets without adverse effects on broiler growth; and
ii) Enzyme supplementation will improve the utilisation of the diets by broilers.

MATERIALS AND METHODS

The study, consisting of 2 experiments (1 and 2) was carried out at Ratish Poultry farm, Nausori, Fiji where ECM is readily available from Fiji Co-operative Dairy Company Limited and Copra Millers Fiji Limited.

*Corresponding author: diarra_s@usp.ac.fj ; sikadi2012@gmail.com

The research committee of the University of the South Pacific approved the experimental protocol.

The protein sources were analysed for proximate composition and amino acid profiles (Tables 1 and 2) and used in the formulation of the experimental diets. Eight broiler starter and finisher diets containing 230 and 200 g/kg crude protein, respectively were formulated (Table 3). The diets consisted of a control without ECM and three other diets containing 150, 300 and 450 g/kg ECM with and without enzyme. All diets were based on fish meal and meat and bone meal as main protein sources. Challenzyme 1309A, a complex enzyme from Beijing Challenge Bio-Technology Company Limited, with the following enzyme activities; β-glucanase 800 U/g, xylanase 15000 U/g, β-mannanase 100 U/g, α-galactosidase 100 U/g, Protease 8000 U/g, amylase 500 U/g, pectinase 500 U/g and cellulase 300 U/g was used for the study. All diets were based on fish and meat and bone meals as protein sources.

A total of 168 day-old Cobb 500 broiler chicks purchased from Pacific feeds limited, Suva, Fiji were warm brooded on deep litter with wood shavings as litter material for a period of 7 days on commercial starter feed. On day 8, the birds were weighed individually (232.9 ± 3.58 g; 1.54 CV) and allotted to 28 cages (65.5 cmõ 50 cm × 35.5 cm) containing 5 birds each and allowed to adapt for two days. The experimental diets were fed to each birds in 4 pens in a factorial arrangement (4 ECM x 2 enzyme) laid in a completely randomized design. The experiment lasted for 30 days (10 -40 d). Feed and water were provided *ad libitum* throughout the duration of the experiment. The birds were exposed to 22 hours lighting during the experimental period.

Data on growth parameters (feed intake, weight gain, and feed conversion ratio) were monitored throughout the experiment. Feed intake was calculated by difference between the quantities fed and left-over. Body weight gain was obtained by difference between the initial and final weights. Feed conversion ratio (FCR) was calculated as the ratio of feed consumed by weight gained.

At d 33, one bird having the closest weight to the group mean was selected from each cage (4 birds per treatment) and placed in individual cages for digestibility studies. After 3 days of adaptation to the cages, weighed quantities of feed were fed and excreta samples collected from each bird for a period of 4 days. Excreta samples were oven-dried at 60º C for 48 hours, ground and analyzed for proximate composition and apparent total tract digestibility was calculated as:

$$\%\ \text{Nutrient Digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient in faeces}}{\text{Nutrient intake}} \times 100$$

At the end of the experiment (day 40), all birds

Table 1. Proximate composition, NDF and ADF (g/kg), and metabolisable energy (MJ/kg) content of the experimental protein sources

Constituents	Protein sources		
	FM	MBM	ECM
ME (MJ/kg)	11.31	13.44	10.88
Dry matter	725	879	887
Crude protein	531	481	184
Ether extract	106	253	120
Ash	117	144	49
Crude fibre	5	21	189
NDF	222	250	441
ADF	26	82	271
NSP	-	-	419

ME: metabolisable energy (calculated); FM: fish meal; MBM: meat and bone meal; ECM: expeller copra meal, NSP: non-starch polysaccharides; NDF: Neutral Detergent Fibre; ADF: Acid Detergent Fibre

were fasted overnight but allowed access to water. The birds were weighed early in the morning and euthanized by decapitation for carcass and organ measurements. Slaughtered birds were scalded in hot water (about 55°C) for about one minute, plucked manually and eviscerated. The eviscerated chickens were weighed and dressing out percentage was calculated as:

$$\% \text{ dressing} = \frac{\text{carcass weight}}{\text{live weight}} \times 100$$

Gut segments (crop, proventriculus, gizzard, small intestine and caeca) and annex glands (liver, pancreas) were also removed and weighed using an electronic scale sensitive to 0.1 gram and expressed as percentage of the live weight.

Data collected were subjected to ANOVA (Steel and Torrie, 1980) of the GLM in SPSS (SPSS for Windows, version 22.0; IBM Corp., Armonk, NY, USA). Individual birds were the experimental units for weight change, carcass and organ measurements and nutrient digestibility whereas cages were the experimental units for feed intake. Treatment means were compared using the Least Significant Difference (LSD) and significant differences were reported at 5% level of probability.

RESULTS AND DISCUSSION

Data pertaining to growth performance of the broilers are presented in Table 4. During the starter phase (10-21days), there were no effects on feed intake and FCR ($P>0.05$). Weight gain was improved on control and 150 ECM diet compared to 300 g/kg without and 450 g/kg with enzyme ($P<0.05$). In the main effects, increasing ECM level significantly ($P<0.05$) reduced feed intake and weight gain but had no effect on FCR ($P>0.05$). Enzyme supplementation had no effect on the growth parameters observed ($P>0.05$). No mortality was recorded during the course of the experiment.

In the starter phase, feed intake and FCR were not affected by the interaction of copra and enzyme

Table 2. Amino acid composition of the experimental protein sources (mg/100 mg DM)

Amino acid	Protein sources (mg/100 mg)		
	FM	MBM	ECM
Aspartic acid	4.58	3.61	1.48
Threonine	2.16	1.67	0.56
Serine	2.13	1.90	0.79
Glutamic acid	6.68	5.63	3.12
Proline	2.84	3.20	0.62
Glycine	4.61	5.21	0.81
Alanine	3.44	3.16	0.80
Valine	2.27	1.95	0.89
Isoleucine	1.85	1.45	0.56
Leucine	3.46	2.87	1.10
Tyrosine	1.50	1.18	0.47
Phenylalanine	1.87	1.56	0.74
Histidine	1.50	1.26	0.39
Lysine	3.84	2.75	0.64
Arginine	3.29	3.12	2.35
Cysteine	0.36	0.25	0.28
Methionine	1.41	0.90	0.31
Tryptophan	0.46	0.30	0.15

FM: fish meal; MBM: meat and bone meal; ECM: expeller copra meal; DM: Dry matter

probably due to the similarity in nutrient content of the experimental diets on one hand and the lower energy requirements of young broilers on the other. Poultry consume feed to meet its requirements of energy (NRC, 1994; Smith, 2001; Classen *et al.,* 2016). The improved weight gain on 150 g/kg ECM diet is contrary to the findings of Sundu *et al.* (2004) who reported reduced gain in 4-14 weeks old broilers fed 100 g/kg dietary ECM. In the study cited above broilers were fed ECM in corn-soybean diets against corn-animal protein diets in the current study. The superiority of animal over plant protein sources is well documented (Vieira and Lima. 2005; Bhuiyan *et al.,* 2012a; Hossain *et al.,* 2012; 2013; Devi and Diarra, 2017). Devi and Diarra (2017) reported improved weight gain in broilers fed ECM in corn-animal protein as compared to corn-soybean diets and attributed this to increased nutrient availability from animal protein sources in the former diet. Possible beneficial effects of ECM fibre on the gut of young birds could also be a reason for improved weight gain on the ECM diets. Early feeding of ECM mannan-oligosaccharides improved intestinal enterocyte length and villus surface area resulting in better nutrient utilisation and weight gain in broilers (Noy *et al.,* 2001).

In the finisher phase (22-40 days) feed intake and weight gain were significantly affected by ECM and enzyme supplementation (P<0.05). Feed intake and weight gain were reduced on 450 g/kg diets and 300 g/kg diet without enzyme (P<0.05). Like in the starter phase, there was no interaction effect on FCR during the finisher phase (P>0.05). The main effects showed decreased feed intake, weight gain and poorer FCR with increasing ECM level (P<0.05). Enzyme addition had no effects on feed intake, weight gain and FCR (P>0.05). The finisher phase showed reduced FI and WG in the interaction effects above 300 g/kg ECM diets. Significant interaction effects (P<0.05) was observed during the phase. Birds fed 450 and 300 g/kg ECM diet without enzyme consumed less feed and gained less weight (P<0.05). In the main effects, feed intake and weight gain were reduced and FCR increased with increasing level of ECM above 150 g/kg (P<0.05). Enzyme addition did not affect the growth parameters (P>0.05).

Sundu *et al.* (2006) observed similar trend in broilers fed corn-soybean diets at 0, 100, 300 and 500 g/kg ECM supplemented with Hemicell®, Allzyme SSF® and Gamanase® and their combination. Several authors have attributed lower intake of ECM-based diets by poultry to the NSP (Sundu *et al.,* 2009; Diarra *et al.,* 2014; Devi and Diarra, 2017; Diarra *et al.,* 2018). The reason for poor performance above 300 g/kg in the current study was not clear but reduced feed intake due to longer digesta transit time in the gastro-intestinal tract (GIT) could be speculated. Several authors (Svihus *et al.,* 2002; Svihus, 2011; Mateos *et al.,* 2012) have reported longer digesta transit leading to poor performance of poultry fed ECM-based diets. Enzyme supplementation could not improve weight gain on 300 g/kg ECM. It is possible that the level of enzyme (0.3 g/kg) used in the diet was not sufficient to hydrolyse the ECM fibre. The effect of enzyme source and concentration on the utilisation of ECM is well documented (Sundu *et al.,* 2009; Diarra *et al.,* 2015).

From the results of nutrient digestibility of the broilers (Table 6), it is evident that there was no significant (P>0.05) interaction effect on dry matter, crude protein and crude fibre digestibility, but there was a significant interaction effect on fat digestibility (P<0.05). Addition of ECM depressed fat digestibility, but enzyme supplementation improved fat digestibility of the 300 g/kg ECM similar to the control diets (P<0.05). In the main effects, the digestibility of all nutrients reduced with increasing level of ECM (P<0.05). Enzyme supplementation did not affect dry matter and crude protein digestibility (P>0.05) but improved crude fibre and ether extract digestibility (P<0.05).

Dietary NSP concentration, class and age of birds are reported to affect nutrient digestibility in poultry (Choct and Annison, 1990; Carré *et al.,* 1995). Carré *et al.* (1995) found lower digestibility of corn-soybean diets in adult broilers compared to cockerels. Dietary NSP binds bile salts, cholesterol, lipids (Vahouny *et al.,* 1980:1981, cited in Choct, 1997) and reduces efficient absorption of nutrients in the intestine wall (Johnson and Gee, 1981, cited in Choct, 1997). NSPs also increase

Table 3. Ingredient composition and calculated nutrient content (g/kg, as fed basis) of the experimental diets

Ingredients (g/kg)	Starter diets								Finisher diets							
	ECM with no enzyme				ECM with enzyme				ECM with no enzyme				ECM with enzyme			
	0	150	300	450	0	150	300	450	0	150	300	450	0	150	300	450
Corn	550.1	453	355.8	258.8	550.1	452.6	355.5	258.5	550.3	468.8	389.8	310.4	550.3	464.8	389.6	310.2
Wheat bran	110	90.6	71.2	51.8	110	90.5	71.1	51.9	145.1	104.4	64.9	25.2	145.1	104.3	64.8	25.1
Fishmeal	94.2	82.6	71.1	59.6	94.2	82.6	71.2	59.7	89.4	78.8	67.9	57.1	89.4	78.8	67.9	57.1
MBM	188.4	165.3	142.4	119.3	188.4	165.3	142.4	119.3	158.7	137.5	115.9	94.3	158.7	137.6	115.9	94.3
Copra meal	0	150	300	450	0	150	300	450	0	150	300	450	0	150	300	450
Coral sand	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Limestone	20	20	20	20	20	20	20	20	10	10	10	10	10	10	10	10
*Premix	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	1	2	2.5	3	1	2	2.5	3	0.8	1	1.5	2	0.8	1	1.5	2
Methionine	0.8	1	1.5	2	0.8	1	1.5	2	0.3	0.5	0.6	0.6	0.3	0.5	0.6	0.6
Enzyme	-	-	-	-	0.3	0.3	0.3	0.3	-	-	-	-	0.3	0.3	0.3	0.3
Salt	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Calculated nutrient content																
Crude protein	230	230	230	230	230	230	230	230	200	200	200	200	200	200	200	200
ME (MJ/kg)	12.39	12.41	12.44	12.46	12.39	12.41	12.44	12.46	12.19	12.34	12.51	12.68	12.19	12.28	12.50	12.67
Lysine	12	13	12	12	12	13	12	12	11	11	10	10	11	11	10	10
Methionine	5	5	6	6	5	5	6	6	5	5	4	4	5	5	4	4

MBM, meat and bone meal; ECM: expeller copra meal; ME: metabolisable energy; *Premix (Vitamin and mineral) Bio-mix supplied/kg diet, vitamin A: 10 000 IU, vitamin D_3: 2000 IU, vitamin E: 23 mg, niacin: 27.5 mg, vitamin B_1: 1.8 mg, B_2: 5 mg, B_6: 3 mg, B_{12}: 0.015 mg, vitamin K: 3.2 mg, pantothenic acid:7.7mg, biotin:0.06 mg, folic acid: 0.75 mg, choline chloride: 300 mg, cobalt: 0.2 mg, copper: 3 mg. iodine: 1mg, iron: 20 mg, manganese: 40 mg, selenium: 0.2 mg, zinc: 30 mg, anti-oxidant: 1.25 mg.

Table 4. Growth performance of broiler starter fed different ECM (g/kg) levels with animal protein sources and Challenzyme supplementation

Treatment		Feed intake (kg)			Weight gain (kg)			FCR (feed: gain)		
Copra	**Enzyme**	**10-21 d**	**22-40 d**	**10-40 d**	**10-21 d**	**22-40 d**	**10-40 d**	**10-21 d**	**22-40 d**	**10-40 d**
0	No	4.49	15.16^{ab}	19.66^{a}	1.34^{a}	5.78^{ab}	7.12^{a}	3.35	2.63	2.77
	Yes	4.50	16.06^{a}	20.15^{a}	1.37^{a}	6.28^{a}	7.57^{a}	3.28	2.57	2.67
150	No	4.46	14.47^{bc}	18.93^{a}	1.33^{a}	5.43^{b}	6.76^{ab}	3.35	2.67	2.81
	Yes	4.34	14.91^{b}	19.25^{a}	1.28^{ab}	5.40^{b}	6.68^{ab}	3.39	2.76	2.88
300	No	3.96	12.90^{c}	16.86^{b}	1.15^{c}	4.40^{c}	5.55^{c}	3.44	2.94	3.05
	Yes	4.29	14.72^{bc}	19.01^{a}	1.27^{b}	5.41^{b}	6.69^{ab}	3.37	2.72	2.84
450	No	4.02	13.53^{c}	17.54^{ab}	1.24^{b}	4.66^{c}	5.90^{c}	3.24	2.91	2.98
	Yes	3.84	12.74^{c}	16.57^{b}	1.10^{c}	4.38^{c}	5.48^{c}	3.48	2.91	3.03
SEM		0.146	0.421	0.509	0.018	0.215	0.208	0.091	0.071	0.056
Main effects										
Copra										
0		4.50^{a}	15.61^{a}	19.90^{a}	1.36^{a}	6.03^{a}	7.35^{a}	3.31	2.60^{b}	2.72^{b}
150		4.40^{ab}	14.69^{b}	19.09^{a}	1.31^{b}	5.41^{b}	6.72^{b}	3.37	2.72^{ab}	2.84^{ab}
300		4.12^{bc}	13.81^{c}	17.93^{b}	1.21^{c}	4.90^{c}	6.12^{c}	3.40	2.83^{a}	2.94^{a}
450		3.93^{c}	13.13^{c}	17.06^{b}	1.17^{d}	4.52^{c}	5.69^{c}	3.36	2.91^{a}	3.00^{a}
Enzyme										
No		4.23	14.02	18.25	1.27	5.07	6.33	3.34	2.79	2.90
Yes		4.24	14.61	18.74	1.26	5.37	6.61	3.38	2.74	2.85
Probabilities										
Copra		0.003	0.000	0.000	0.000	0.000	0.000	0.809	0.001	0.000
Enzyme		0.928	0.059	0.179	0.404	0.060	0.077	0.560	0.325	0.284
Copra*Enzyme		0.324	0.037	0.043	0.000	0.028	0.006	0.293	0.185	0.061

ECM: expeller copra meal; FCR: Feed Conversion Ratio; SEM: Standard Error of Mean; ^{a,b,c}Values within the column with different superscripts differ significantly (P<0.05)

digesta viscosity in the gut which decreases diffusion rate of digestive enzymes and substrates and disturbs their interaction at mucosal surface level (Ikegami *et al.,* 1990, cited in Choct, 1997). Prolonged feeding time of soluble NSP results in adaptive changes such as enlargement of organs, increased digestive secretion and nutrient absorption (Choct, 1997). Increased level of dietary insoluble fibre reduces digesta retention time (Kirwan *et al.,* 1974, cited in Choct, 1997) which may affect nutrient digestibility. The improved fat digestibility on 300 g/kg ECM with enzyme diet was not understood but probably due to differences between plant and animal fats. The reduced fat digestibility on 450 g/kg ECM diets may be attributed to the inability of the broiler to digest ECM fat at this level of inclusion. The effect of fat source on nutrient digestibility is well documented. Allahyari-Bake and Jahanian (2016) found improved ether extract digestibility of birds fed soy oil and soy free fatty acid in corn-soybean as well as in corn-soybean-wheat meal based diets. Huo *et al.* (2018) fed 50 g/kg lard, sesame oil and flaxseed oil in corn-soybean meal based diets to broilers and found improved crude fat digestibility in sesame and flaxseed oil compared to lard. The authors suggested that fat source could possibly affect nutrient digestibility. Higher ECM levels increases the residual oil content and this may have contributed to improved fat digestibility in finishing broilers in the current study.

In the main effects, the digestibility of most nutrients was reduced with increasing ECM level further confirming the adverse effect of ECM fibre on nutrient digestibility. Sundu *et al.* (2006) observed reduced dry matter (DM) digestibility on 100 g/kg ECM in 4-14-day old Ross broilers fed corn-soybean diets but supplementation with Hemicell®, Allzyme SSF® and Gamanase® or their combination improved DM digestibility by the birds. The authors attributed poor performance to quality of ECM. The improved crude fibre and ether extract digestibility of the enzyme supplemented ECM up to 300 g/kg may explain the enhanced growth performance observed on this diet.

The results of carcass studies and gut measurement of broilers are presented in Table 5. There were no significant interaction or main effects of ECM and enzyme supplementation on any of the carcass parameters studied (P>0.05). This may suggest that all diets met the requirements of the birds for muscle development. Devi and Diarra (2017) found no effect of 150 g/kg dietary ECM in corn-animal protein diets on thigh and drumstick yields. Contrary to the findings of this study, however, Diarra *et al.* (2014) observed reduced dressing percentage and breast weights in finishing broilers fed cassava-ECM diets compared to the control commercial feed. As earlier mentioned, differences in feed processing and composition of basal diet are all possible factors affecting the utilisation of ECM by poultry.

Gut measurements results of the broilers showed no interaction effects on the weights of liver, crop, proventriculus, gizzard and small intestine (P>0.05). Pancreas weight was reduced on negative control (without enzyme) compared to 300 g/kg without enzyme but did not differ among positive control, 150 with enzyme and 450 g/kg ECM diets (P<0.05). Heavier caeca weight was observed on 150 g/kg without enzyme, 300 g/kg with enzyme and 450 g/kg without enzyme ECM diets (P<0.05).

In the main effects, there was a significant effect of ECM on the weight of all gut segments (P<0.05). The liver was lighter on 450 g/kg ECM (P<0.05). Birds fed 150 g/kg ECM, had lighter crop compared to control but crop weight did not differ among the ECM diets (P<0.05). Proventriculus weight was increased on the ECM diets (P<0.05). A lower (P<0.05) gizzard weight was recorded on control compared to ECM-based diets. Birds fed 450 g/kg ECM had the heaviest small intestines (P<0.05). Enzyme addition reduced (P<0.05) caeca weight but did not affect the rest of the segments (P>0.05). There were no interaction or main effects of ECM and enzyme addition on the relative weights of carcass and cuts (breast, thigh and drumstick).

Heavier pancreas on the 300 g/kg ECM with enzyme was not clear but could be due to longer digesta retention which might have increased pancreatic secretion to hydrolyse fibre. Diarra *et al.* (2014) reported heavier pancreas in broilers fed cassava-ECM

Table 5. Relative weights of carcass and gut segments (% live weight) of the broilers fed different ECM (g/kg) levels with animal protein sources and Challenzyme supplementation

Treatment		Dressing	Breast	Thigh	Drum-stick	Liver	Pancreas	Crop	Proven-triculus	Gizzard	Small Intestine	Caeca
Copra	Enzyme											
0	No	72.92	21.89	10.65	1.80	1.69^{c}	0.45	0.28	1.59	2.67	0.22^{bc}	9.73
	Yes	74.37	23.66	11.80	2.03	2.06^{ab}	0.51	0.24	1.58	2.97	0.12^{c}	11.07
150	No	73.29	20.52	11.34	1.82	1.80^{bc}	0.23	0.39	2.05	2.74	0.46^{a}	10.86
	Yes	71.62	20.45	10.66	1.62	2.13^{ab}	0.22	0.45	1.90	2.67	0.28^{b}	10.91
300	No	69.18	19.13	10.65	1.74	2.44^{a}	0.36	0.28	2.00	2.86	0.28^{b}	10.38
	Yes	73.89	22.19	11.29	1.88	1.93^{bc}	0.22	0.45	1.95	2.68	0.45^{a}	10.19
450	No	71.78	20.50	11.46	1.54	2.20^{ab}	0.34	0.34	1.97	3.60	0.41^{a}	10.48
	Yes	72.02	19.14	10.87	1.59	2.23^{ab}	0.41	0.35	2.06	3.05	0.28^{b}	11.80
SEM		1.338	1.145	0.433	0.104	0.104	0.078	0.047	0.144	0.151	0.036	0.548
Main effects												
Copra												
0		73.64	22.78	11.23	1.92^{a}	1.87^{b}	0.48^{a}	0.26^{b}	1.58^{b}	2.82^{b}	0.17^{b}	10.40
150		72.45	20.49	11.00	1.72^{a}	1.97^{b}	0.23^{b}	0.42^{a}	1.97^{a}	2.70^{b}	0.37^{a}	10.88
300		71.53	20.66	10.97	1.81^{a}	2.18^{a}	0.29^{ab}	0.36^{a}	1.97^{a}	2.77^{b}	0.36^{a}	10.29
450		71.90	19.82	11.16	1.57^{b}	2.21^{a}	0.38^{ab}	0.34^{ab}	2.01^{a}	3.33^{a}	0.34^{a}	11.14
Enzyme												
No		71.79	20.51	11.03	1.72	2.03	0.34	0.32	1.90	2.97	0.34^{a}	10.36
Yes		72.97	21.36	11.16	1.78	2.09	0.34	0.37	1.87	2.84	0.28^{b}	10.99
Probabilities												
Copra		0.433	0.084	0.921	0.019	0.007	0.022	0.017	0.020	0.001	0.000	0.375
Enzyme		0.223	0.304	0.672	0.452	0.456	0.955	0.156	0.789	0.251	0.027	0.118
Copra*Enzyme		0.140	0.250	0.114	0.230	0.001	0.560	0.179	0.869	0.070	0.000	0.369

ECM: expeller copra meal; SEM: Standard Error of Mean; [a,b,c]Values within the column with different superscripts differ significantly (P=0.05);

diets compared to commercial feed and attributed this to increased pancreatic activity for hydrolysis of the fibrous diet. Devi and Diarra (2017) also observed similar trend of pancreas weight on corn-soybean diets containing 150 g/kg ECM. The pattern of caeca weight was not understood but probable increased fibre fermentation on the 150 g/kg ECM without enzyme and low feed intake or slower digesta transit above this level of ECM inclusion are speculated. Shortening of digesta transit time as a result of feeding high levels of insoluble NSP (Choct, 1997) and increase transit time on high levels of soluble NSP (Choct *et al.,* 1996) have been reported. Our findings are contrary to those of Diarra *et al.* (2014) who reported no effect of cassava-ECM diets on caeca weight of finishing broilers. Factors including source of ECM, inclusion level and diet composition may affect gut weight of birds.

The reduced liver weight on 450 g/kg ECM diet was attributed to the reduced intake of this diet in the main effects. The 150 g/kg ECM diet might have transited faster along the gastro-intestinal tract resulting in lighter crop on this diet. Possible increase in digestive secretion in the proventriculus and increased gizzard activity with increasing ECM may explain the weight pattern of these gut segments. Diarra *et al.* (2014) found heavier gizzard on cassava-ECM diets of finishing broilers compared to commercial diet and attributed this to digesta retention time on the fibrous

Table 6. Nutrient digestibility (%) of the broiler chickens fed different levels of ECM (g/kg) with animal protein sources and Challenzyme supplementation

Treatment		Dry matter	Crude protein	Crude fibre	Ether extract
Copra	**Enzyme**				
0	No	88.94	63.27	61.68	78.89^{a}
	Yes	91.37	69.87	74.80	81.34^{a}
150	No	83.51	64.12	49.78	71.74^{b}
	Yes	84.41	64.59	65.91	66.02^{c}
300	No	84.99	46.18	48.38	66.11^{c}
	Yes	83.63	54.48	55.37	80.82^{a}
450	No	83.99	37.64	35.50	61.54^{c}
	Yes	83.61	42.69	48.38	63.97^{c}
SEM		1.264	4.450	3.884	1.529
Main effects					
Copra					
0		90.15^{a}	66.57^{a}	68.24^{a}	80.12^{a}
150		83.96^{b}	64.35^{a}	57.84^{b}	68.88^{c}
300		84.31^{b}	50.33^{b}	51.87^{b}	73.47^{b}
450		83.80^{b}	40.17^{c}	41.94^{c}	62.76^{d}
Enzyme					
No		85.36	52.80	48.84^{b}	69.57^{b}
Yes		85.75	57.91	61.11^{a}	73.04^{a}
Probabilities					
Copra		0.000	0.000	0.000	0.000
Enzyme		0.662	0.118	0.000	0.004
Copra*Enzyme		0.484	0.835	0.697	0.000

ECM: expeller copra meal; SEM: Standard Error of Mean; ^{a,b,c}Values within the column with different superscripts differ significantly (P=0.05)

diets. Amerah *et al.* (2009) also reported increased gizzard volume with increasing dietary structural components. Copra meal fibre is reported to increase secretion of digestive enzymes and gizzard development (Svihus, 2011; Mateos *et al.,* 2012; Kheravii *et al.,* 2018). The weight of small intestine increased on 450 g/kg ECM with enzyme probably due to longer digesta retention and an attempt by this segment to increase enzymatic hydrolysis. These findings agree with the report of Diarra *et al.* (2014) who observed heavier small intestine weights in birds fed diets containing 500 g/kg ECM with Allzyme SSF. The authors attributed heavier weights to increased digesta retention time on the test diet. In another study, Sundu (2011) attributed heavier small intestine weight of birds fed an ECM-based compared to corn-soy diets to larger body, beak and feed particle size.

CONCLUSIONS

Based on the experimental results, it is concluded that feeding up to 300 g/kg ECM fed with animal protein sources with enzyme supplementation has no adverse effects on broiler growth and nutrient digestibility. These findings would reduce cost of broiler production in coconut producing regions. More research is recommended into ECM source, diet composition, enzyme product and concentration.

ACKNOWLEDGEMENTS

The University of the South Pacific is duly acknowledged for funding the research (Grant No. F5136 RI001-ACT-PROG). Authors are grateful to Prof. Ravi Ravindran of Massey University, New Zealand for assisting with chemical analysis of the feed ingredients. Ratish Chandra's farm, Fiji for provided space and facilities for the research.

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Received on 28-05-2019 and accepted on 24-06-2019

Indian J. Anim. Nutr. 2019. 36 (2): 198-201
doi: 10.5958/2231-6744.2019.00032.X

Indian Journal of Animal Nutrition

Effect of Dietary Incorporation of *Coriander Seed Meal* on Production Performance of Japanese quail

N. Bala Chenna Reddy, D. Srinivas Kumar*, K. Raja Kishore, K. Naga Raja Kumari

Department of Animal Nutrition, NTR College of Veterinary Science, Gannavaram-521102
Krishna (A.P), India

ABSTRACT

The present experiment was conducted to evaluate the effect of incorporation of coriander seed meal (CSM) in the diet on the performance and carcass characteristics of Japanese quail. One hundred and fifty day-old quail chicks were randomly allotted to five dietary treatment groups with 3 replicates of 10 birds for 5 weeks. The CSM was ground and included at 0% (T_1; Control), 0.5 (T_2), 1.0 (T_3), 1.5 (T_4) and 2.0 (T_5) percent levels in iso-caloric and iso-nitrogenous broiler quail diets to meet the nutrient requirements as per NRC (1994).Body weight gain and feed intake were recorded while feed efficiency was calculated. There was a significant increase (P<0.01) in body weight gain, overall feed intake and improved (P<0.01) FCR with incorporation of CSM at 2.0% in the diet compared to the control group. There was no significant difference in the carcass traits with respect to dressing percentage and percent weight of heart, liver, gizzard or giblet. However, incorporation of CSM at 2.0% level had increased the carcass yield, ready to cook yield (P<0.05) and meat to bone ratio (P<0.01) compared to the control group. The feed cost/kg gain decreased (P<0.01)with incorporation of CSM at 2.0% level in the diet. Thus, it is concluded that CSM can be safely incorporated at 2% level in quail diets without any adverse effects.

Key words: Carcass characteristics, Coriander seed meal (CSM), Production performance, Quail

INTRODUCTION

Increase in demand for good quality animal protein, health consciousness, and change in food habits, moving trend towards fast foods of the consumer hasten the entrepreneur to seek for fast growing birds other than chicken. Quail is the one among the alternative in poultry with 24% protein in meat, and comes to market age by the end of 5thweek, lesser the investment required for production. In general practice usage of antibiotics as growth promoters has been banned in poultry. Now-a-days, most of the research work is concentrated on use of phytobiotics in poultry diets both for improving the production as well as value addition. Herbs are used since ages for their flavours, redolence, food or even remedy. Coriander (*Coriandrumsativum* L.) is documented in ayurvedic literature as a medicinal herb (The Ayurvedic Pharmacopeia of India., 2010). It is an umbelleferous annual plant of parsley family. Incorporation of coriander seed up to 0.3% resulted in improved body weights and better FCR in broilers (Saeid and Nasry, 2010) while, other studies (Sunbul *et al.* 2010; Farah and Jaff,201; Jang, 2011) reported better performance in broilers up to 2% level of incorporation of coriander seed in diet. Most of the research has been carried out by incorporation of coriander seed in broiler diets. On the other hand, research on utilization of coriander seed in quail diets is scanty. Hence, the present study was undertaken to assess the performance of quail in terms of growth rate, carcass yield and economics of supplementation of CSM at various levels.

MATERIALS AND METHODS

One hundred and fifty day-old quail chicks were procured and randomly allotted into 5 groups, each with 3 replicates of 10 chicks. Chicks were wing banded and weight of the chick was recorded. The experiment was carried out for 5 weeks in a completely randomized design (CRD). During the experiment, coriander seed was ground and was included at 0% (T_1; Control), 0.5 (T_2), 1.0 (T_3), 1.5 (T_4) and 2.0 (T_5) per cent levels in iso-caloric and iso-nitrogenous quail diets (Table 1) formulated to meet nutrient requirements as per NRC (1994). All the chicks were housed in battery brooders under uniform management conditions. Feed and water were provided *ad libitum*. The feed offered and feed

*Corresponding author: kumardhulipalla@rediffmail.com; Phone: 08676-253782 Ext. 226 (Off); Mobile: 9951384777

Table 1. Ingredient (%) and chemical composition (% DM basis) of quail diets

Constituent/ Diet	T_1 (Control)	T_2	T_3	T_4	T_5	Cost/kg (₹)
Maize	49.80	49.5	49.40	49.20	49.00	16.00
De-oiled rice bran	8.30	8.10	7.70	7.40	7.10	13.50
Soybean meal	34.50	34.50	34.50	34.50	34.50	38.00
Fish meal	5.00	5.00	5.00	5.00	5.00	30.00
Coriander seed	0.00	0.50	1.00	1.50	2.00	80.00
Di-calcium phosphate	0.30	0.30	0.30	0.30	0.30	26.00
Shell grit	1.20	1.20	1.20	1.20	1.20	0.00
Salt	0.25	0.25	0.25	0.25	0.25	3.00
Trace min mix	0.15	0.15	0.15	0.15	0.15	240.00
Feed additives	0.50	0.50	0.50	0.50	0.50	1116.00
Total	100	100	100	100	100	
ME* kcal/kg	2900.33	2900.58	2903.13	2904.53	2905.93	
Crude protein (%)	24.03	24.05	24.04	24.04	24.05	
Feed cost/100 kg (₹)	2669.00	2701.00	2734.00	2767.00	2800.00	

*Calculated value

leftover was weighed daily, to quantify the amount of feed consumed. The data for growth rate was recorded at weekly intervals.

At the end of study period (5th week), two birds per replicate and thus a total of 6 birds per experimental diet were randomly selected, weighed and slaughtered. The data on dressing percentage, carcass yield, meat bone ratio, ready-to-cook yield and per cent weight of heart, liver, gizzard and giblet were recorded. All the data were analyzed statistically (SPSS, 17th Version) as per Snedecor and Cochran (1993) and comparison of means was done using Duncan's multiple range tests (Duncan, 1955).

RESULTS AND DISCUSSION

Data pertaining to body weight gain, feed intake and FCR under different dietary treatments are presented in table 2. The mean body weight gain (g) increased significantly (P<0.01) with increased level of inclusion of coriander seed meal from 1.0 to 2.0% in diet of quails as compared to the control group. The increased body weight gains observed in quails upon feeding coriander seed meal in the diet might be attributed to enhanced liver function (Hernandez *et al.* 2004) or due to appetizing and stimulatory effects of CSM on digestion process (Cabuk *et al.,* 2003). The results of the present investigation are in agreement with earlier reports which indicate increased body weight gains in quails (Guler *et al.,* 2005) and broilers (Hamodi *et al.,* 2010; Farag, 2013;Abou-Elkhair *et al.,* 2014; Rashid *et al.,* 2014) as a result of incorporation of coriander seed in diet. However, Naeemasa *et al.* (2015) reported no effect (P>0.05) on body weight gain in broilers fed coriander powder in the diet.

Feed intake for overall growth period (0-5 weeks) was higher (P<0.01) in quails fed diets incorporated with CSM at 1.0, 1.5 and 2.0% as compared to control group

Table 2. Effect of incorporation of CSM in diet on body weight gain, feed intake, FCR and feed cost/kg gain of quails

Parameter	T_1	T_2	T_3	T_4	T_5	Level of significance
Body weight gain (g)	157.13^{a}±1.90	159.91^{a}±2.41	167.46^{b}±1.89	175.36^{c}±3.58	184.17^{d}±0.23	P<0.01
Overall feed intake (g)	581.16^{a}±2.04	590.10^{a}±3.52	607.01^{b}±8.11	608.20^{b}±1.92	609.10^{b}±2.50	P<0.01
Feed conversion ratio	3.70^{c}±0.06	3.69^{c}±0.07	3.62^{bc}±0.02	3.47^{b}±0.06	3.30^{a}±0.01	P<0.01
Feed cost/kg (₹)	$98.75^{b\pm}$1.54	99.72^{b}±2.00	99.09^{b}±0.48	$96.03^{ab\pm}$1.66	$92.60^{a\pm}$0.33	P<0.05

Table 3. Effect of incorporation of CSM in diet on carcass characteristics of quails

Parameter	T_1	T_2	T_3	T_4	T_5	Level of significance
Carcass yield (g)	106.5^{a}±1.94	111.17^{ab}±2.67	116.00^{ab}±7.76	117.17^{ab}±4.48	123.17^{b}±6.29	P<0.05
Dressing (%)	60.47±1.02	60.56±2.16	60.83±1.77	60.97±1.32	60.98±1.49	NS
Ready to cook yield (g)	$114.83^{a±}$2.63	119.50^{ab}±2.70	125.67^{ab}±7.99	126.83^{ab}±5.46	132.83^{b}±6.69	P<0.05
Meat: bone ration	5.70^{a}±0.01	5.83^{b}±0.01	6.21^{c}±0.01	7.06^{d}±0.01	7.13^{e}±0.03	P<0.01
Heart (%)	0.84±0.12	0.85±0.13	0.86±0.12	0.88±0.12	0.89±0.09	NS
Liver (%)	1.68±0.39	1.69±0.19	1.71±0.17	1.73±0.26	1.74±0.22	NS
Gizzard (%)	2.17±0.15	2.18±0.11	2.19±0.23	2.21±0.02	2.22±0.14	NS
Giblet (%)	4.69±0.45	4.72±0.31	4.76±0.44	4.82±0.45	4.85±0.31	NS

but incorporation of CSM at 0.5% in feed did not show any significant effect on feed intake over control group. The improvement in the feed intake observed with the addition of CSM might be attributed to the presence of linalool. Linalool has an appetizing effect and stimulates the digestive process in animals (Çabuk *et al.,* 2003). Similarly, increased feed intakes upon feeding diets containing coriander seed were reported in Japanese quails (Esteghamat, 2014) and broiler chicken (Hamodi *et al.* 2010; Al-Mashhadani *et al.* 2011; Farag, 2013; Naeemasa *et al.* 2015). In contradiction to the present finding, Kumari *et al.* (2014) reported significantly (P<0.05) lower feed intake in Vanaraja chicken fed basal ration mixed with 2.5% coriander seed meal as compared to the control. On the other hand, no effect (P>0.05) of feeding coriander seeds in the diet on feed intake of broiler chicken.was reported by other research workers (Abou-Elkhair *et al.,* 2014;Rashid *et al.* 2014; Saleh *et al.* 2014).

The FCR improved significantly (P<0.01) in quails fed diets incorporated with CSM at 1.5 and 2.0% level in comparison to the control group, indicating better feed utilization in terms of body weight gain. These findings are in agreement with those of other researchers (Guler *et al.,* 2005; Hamodi *et al.,* 2010; Al-Mashhadani *et al.,* 2011; Farag, 2013; Abou-Elkhair *et al.,* 2014; Saleh *et al.,* 2014; Naeemasa *et al.,* 2015). However, Hosseinzadeh *et al.* (2014) and Rashid *et al.* (2014) reported that feeding coriander seed in the diet had no effect (P>0.05) on FCR in broiler chicken.

Data pertaining to carcass characteristics are presented in table 3.Incorporation of CSM at 2.0% level in the diet of quails resulted in increased (P<0.05) carcass yield (g) and ready to cook yield (g) as compared to the control. These results corroborated with the findings of Guler *et al.* (2005), who reported that carcass yield (%) was significantly higher in quails fed 2.0% coriander seed in the diet. On the other hand, Abou-Elkhair *et al.* (2014) and Ramadan *et al.* (2014) reported that feeding of CSM at 2.0% level in the diet had no effect (P>0.05) on carcass weight in broiler chicken. Incorporation of CSM upto 2.0% level in the diet had no effect (P>0.05) on dressing percentage in current study. Rashid *et al.* (2014) also reported that feeding broilers with diets containing CSM up to 1.5% levels had no effect (P>0.05) on dressing yield as compared to the control. In contradiction, Ramadan *et al.* (2014) reported that the dressing percentage increased significantly (P<0.05) in broilers fed 2% coriander seed in the diet as compared to control. Incorporation of CSM up to 2.0% level in the diet had no effect (P>0.05) on per cent weight of heart, liver, gizzard and giblets in quails which was in agreement with the findings of earlier researchers (Abou-Elkhair *et al.,* 2014; Saleh *et al.* 2014; Naeemasa *et al.,* 2015).

There was a significant (P<0.05) decrease in feed cost/kg gain (₹) with incorporation of CSM at 1.5 and 2.0% in diet as compared to the control (Table 2). Similarly, Rashid *et al.* (2014) revealed that total production cost per kg broiler was lower (P<0.05) in birds fed CSM at 1.5% as compared to control group.

CONCLUSIONS

Results of the present study indicate that incorporation of CSM at 2.0% in the diet resulted in

increased carcass yield, ready to cook yield with a concomitant decrease in feed cost/kg gain. Thus, it would be beneficial to incorporate coriander seed meal at 2% in the diet of broiler quails.

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Received on 07-09-2018 and accepted on 03-03-2019

Indian J. Anim. Nutr. 2019. 36 (2): 202-206
doi: 10.5958/2231-6744.2019.00033.1

Indian Journal of Animal Nutrition

SHORT COMMUNICATION

Effect of Betaine Supplementation on Serum Metabolite Profile in Gestating Sows

Alok Mishra[1*], A.K. Verma[2], Asit Das[3], Putan Singh [3] and N.R. Sahoo[4]
Division of Animal Nutrition, ICAR- Indian Veterinary Research Institute,
Izatnagar, Bareilly- 243122, Uttar Pradesh, India

ABSTRACT

Present study was conducted to investigate the effect of betaine supplementation on serum metabolite profile in gestating sows. For the study, eighteen crossbred (*Landrace X Desi*) inseminated sows were randomly distributed into three treatment groups with six sows per treatment in completely randomized design. Animals in T_0 (control) group were fed basal diet, whereas, T_1 and T_2 treatment groups were fed basal diet supplemented with betaine @ 3g/kg dry matter either during late gestation (76 days before to farrowing) or throughout the length of gestation, respectively.There were no significant ($P>0.05$) differences in serum glucose, albumin, globulin, total protein, albumin/globulin ratio and creatinine levels among the groups. whereas, serum cholesterol and triglyceride levels were significantly($P<0.05$) lower in T_2 group as compared to T_0 and T_1groups. Thus, it can be concluded that, dietary betaine supplementation @ 3 g/kg throughout the length of gestation was helpful in decreasing the serum cholesterol and triglyceride levels in sows.

Key words: Betaine, Cholesterol, Gestating sows, Metabolicprofile, Triglyceride

Betaine is a by-product of the sugar beet processing, and chemically a trimethyl derivative of the amino acid glycine. It is commercially available as a feed additive for livestock. Betaine provides three methyl groups which can be used in transmethylation reactions for the synthesis of numerous substances. The dual function of betaine as methyl donor and amino acid gets it involved in protein and energy metabolism Eklund *et al.* (2005). Moreover, under stress situation or disease, methylation reactions are needed for building the immune defense mechanism as well the synthesis of polyamides, which play a role in tissue repair process. Betaine supplementation had shown positive effects regarding mortality reduction under heat stress conditions, improved immunity and the health performance of birds (Khattak *et al.,* 2012; Attia *et al.,* 2016).

Betaine plays an important role in lipid metabolism and improves meat production (Akhavansalamat and Ghasemi 2016). Various studies suggest that lipid metabolism is also affected by betaine (Hanczakowska *et al.,* 1999; Huang *et al.,* 2008; Rojas-Cano *et al.,* 2011; Sales, 2011; Yang *et al.,* 2009), which is considered to be a lipotropic compound. Betaine indirectly stimulates the synthesis of carnitine necessary for the transport of long-chain fatty acids to mitochondria, where they are oxidized (Zabaras-Krick, 1997). According to some authors, betaine enables decreasing the amount of adipose tissue through the stimulation of fatty acid oxidation and contribution to the synthesis of carnitine (Saunderson and McKinlay, 1990); Nakev *et al.,* 2009). Fernandez-Figares *et al.* (2002) observed that betaine can reduces carcass fat concentration in pigs and at the same time it reveals that the addition of 0.5% betaine has no impact on the oxidation and utilization of palmitic acid. This suggests that the effect of betaine on lipid metabolism could be related to mechanisms other than oxidation (Wray-Cahen *et al.,* 2004). Loest *et al.* (2002) found that betaine may decrease the demand for choline methyl groups, thus increasing choline availability for lipid metabolism. This was supported by the findings of

*Corresponding author: Alok Mishra, Ph.D. Scholar dr.mishra04@gmail.com; Present address: [1]PhD Scholar (dr.mishra04@gmail.com), [2]Head and Director-CAFT (vermaak62@gmail.com), [3]Principal Scientist (drasitdas@rediffmail.com, putan60@gmail.com), Animal Nutrition Division, [4]Senior Scientist (vet.nihar@gmail.com), Animal Genetics and Breeding Division, ICAR-IVRI, Izatnagar243122, Uttar Pradesh, India

Yao and Vance (1989). Thus, the present study was carried out to assess the effect of betaine supplementation on serum metabolite profile in gestating sows.

The experimental procedures carried out in the study were approved by the Institutional Animal Ethics Committee. Following a completely randomized design, eighteen healthy crossbred (*Landrace X Desi*) sows, freshly inseminated, were divides in to three groups with six animals in each. The three groups of sows were assigned to three treatment *viz.* T_0 (basal diet), T_1 (basal diet + 3g betaine/kg diet from 76 day of pregnancy to furrowing), and T_2 (basal diet + 3g betaine/kg diet for whole gestation period). The betaine was purchased from Indian Trading Bureau Private Limited, Kolkata, West Bengal, India. The basal diets were formulated as per the recommendations of NRC (1998) (Table 1). The basal feed was provided @ 2.0 kg/day/sow up to farrowing, @ 2.5 kg/day/sow up to 4 days post-farrowing, and thereafter @ 3.5 kg/day/sow up to weaning of piglets with *ad lib* fresh and clean drinking water.

The blood samples from six sows per treatment were collected on 0 day and 114 day post-insemination before feeding and watering in commercially available clot activating tubes to harvest the serum. The harvested serum was subjected to the analysis of serum glucose, total protein, albumin, creatinine, cholesterol and triglyceride using commercial diagnostic kits of Coral Clinical Systems, Tulip Diagnostics, India. The data obtained from the study were subjected to two way analysis of variance. Treatment means were separated by Duncan's multiple range test (Duncan, 1955) and were considered significant at $P<0.05$. All analysis were performed using statistical software package SPSS version 20.0.

Table 1. Chemical and nutrient composition of basal diet

Ingredients	Parts/100 kg
Crushed maize	55
Deoiled soybean meal	13
Wheat bran	30
Mineral mixture*	1.5
Common salt	0.5
Nutrient composition (As fed basis)	
DE (kcal/kg)**	3400
CP (%)***	15

*Composition of mineral mixture (%w/w): Ca, 24.79; P, 9.91; Mg, 0.87; Fe, 0.92; I, 0.078; Cu, 0.17; Mn, 0.22; Co, 0.02; Zn, 0.22; S, 2.04 and Se, 0.002.**Calculated values as fed basis. *** Analyzed values as fed basis

The effect of dietary betaine supplementation on serum metabolites studied during experimental trial is presented in Table 2. There were no significant differences in serum concentrations of glucose (mg/dl), albumin (g/dl), globulin (g/dl), total protein (g/dl), A/G ratio and creatinine (mg/dl) among the groups following betaine supplementation. However, concentrations of cholesterol (mg/dl) and triglyceride (mg/dl) differed significantly among the groups; values being lower in group T_2 as compared to T_0 and T_1 groups (Table 2). The efficacy of betaine in regulating the concentration of cholesterol in pigs shows variable results and seems to depend on both animal and dietary factors. Although the results were inconsistent, but it seems that betaine might affect cholesterol partitioning or enhances the transport of cholesterol. Similarly, Hwang *et al.* (2010) and Fernandez *et al.* (2009) reported that oral supplementation of betaine (4 g/kg) for 15 days before parturition up to lactation in goats resulted in lower triglycerides level than the control group. The supplementation of betaine at 0.2% in sow diet resulted in lower serum concentration of total cholesterol as compared to control (Yang *et al.,* 2009). However, major involvement of betaine in lipid metabolism was in its lipotropic activity. Barak *et al.* (1994) reported that the dietary betaine has been shown to stimulate liver lipid mobilization and alter the blood lipoprotein profile. The natural lipids are mainly composed of triglycerides, which form the principal part of depot lipids in meat systems (Fernandez *et al.,* 1998). Li *et al.* (2017) showed that betaine supplementation decreased the concentration of serum cholesterol and HDL-cholesterol and increased cholesterol level in muscle, which was consistent with

Table 2 Effect of time of betaine supplementation on serum metabolite profile in gestating sows

Treatment†	Days post-insemination		Mean	SEM	Significance		
	0 d	114 d			T	P	T*P
Serum glucose (mg/dl)							
T_0	77.80±1.89	79.03±1.12	78.42±1.06	0.833	0.055	0.378	0.980
T_1	77.88±2.89	79.87±1.71	78.88±1.63				
T_2	79.02±2.47	79.08±2.50	79.05±1.68				
Mean	78.23±1.34	79.33±1.02					
Albumin (g/dl)							
T_0	4.44±0.11	4.27±0.08	4.35±0.07	0.034	0.871	0.049	0.951
T_1	4.40±0.10	4.28±0.08	4.34±0.06				
T_2	4.45±0.06	4.32±0.07	4.38±0.05				
Mean	4.43±0.05	4.29±0.04					
Globulin (g/dl)							
T_0	2.80±0.14	2.57±0.05	2.68±0.08	0.034	0.265	0.047	0.069
T_1	2.75±0.06	2.52±0.05	2.63±0.05				
T_2	2.52±0.05	2.60±0.06	2.56±0.04				
Mean	2.69^{Y}±0.06	2.56^{X}±0.03					
Total protein (g/dl)							
T_0	7.24±0.08	6.83±0.10	7.03±0.08	0.043	0.580	0.001	0.120
T_1	7.15±0.08	6.80±0.08	6.98±0.08				
T_2	6.97±0.10	6.92±0.10	6.94±0.07				
Mean	7.12^{Y}±0.05	6.85^{X}±0.05					
A/G Ratio							
T_0	1.61±0.11	1.67±0.05	1.64±0.06	0.025	0.403	0.728	0.225
T_1	1.61±0.06	1.71±0.05	1.66±0.04				
T_2	1.77±0.02	1.67±0.04	1.72±0.03				
Mean	1.66±0.04	1.68±0.02					
Creatinine (mg/dl)							
T_0	1.31±0.10	1.33±0.10	1.32±0.07	0.032	0.453	0.078	0.555
T_1	1.31±0.06	1.46±0.06	1.38±0.04				
T_2	1.33±0.08	1.50±0.07	1.41±0.06				
Mean	1.31±0.04	1.43±0.05					
Cholesterol (mg/dl)							
T_0	54.42±0.70	47.58±1.18	51.00^{B}±1.22	0.854	0.008	0.001	0.057
T_1	54.48±0.46	45.27±0.68	49.88^{AB}±1.44				
T_2	53.92±0.94	42.82±0.54	48.37^{A}±1.75				
Mean	54.27^{Y}±0.40	45.22^{X}±0.66					
Triglyceride (mg/dl)							
T_0	92.41±0.42	91.43±0.49	91.92^{C}±0.34	0.962	0.001	0.001	0.001
T_1	92.82±0.49	84.47±1.34	88.65^{B}±1.43				
T_2	92.96±0.32	78.62±1.07	85.79^{A}±2.23				
Mean	92.73^{Y}±0.23	84.84^{X}±1.39					

†Sow in control group T_0, no supplementary betaine, where as diet of sow in group T_1 and T_2were supplemented with betaine @3g /kg DM either late gestation or whole gestation, respectively; $^{A,B,\ C/X,Y}$Means with different superscripts in a column/ row differ significantly

the studies by Albuquerque *et al.* (2017) and Yang *et al.* (2009). Zou *et al.* (1998) found that betaine enhanced lipase activity and decreased the concentration of triacylglycerols and cholesterol in serum of laying hens. Similarly, Rao *et al*. (2011) conducted an experiment in broiler with betaine supplementation (0 and 800 mg/kg) to diets containing five concentrations (15, 18, 20, 22 and 24 % crude protein) of methionine in a 2×5 factorial study for serum biochemical. Supplementation of betaine at lower levels of met (15 and 18 g/kg CP) significantly increased the concentration of total protein, triglycerides and total cholesterol in serum. In ducks, supplementing betaine at different levels (0, 0.5, 1.0 and 1.5 g/kg diet) resulted in decreased serum concentration of total and LDL-cholesterol with a concomitant increase in HDL-cholesterol (Awad *et al.,* 2014). Betaine may improve the availability of choline, thus providing more choline for the synthesis of very low-density lipoprotein. Thus, the production of very low-density lipoprotein would prevent the deposition of fat in the liver and stimulate the removal of fat from the liver (Yao and Vance, 1989), it also helped to regulate hepatic cholesterol metabolism in chicks (Yun *et al.* 2015). However, in contrast to the results of present study, Fernandez *et al*. (2009) reported that oral supplementation of betaine (4 g/kg) for 15 days before parturition up to lactation in goats resulted in no significance difference in concentration of glucose, albumin, total protein and creatinine. It was reported by Matthews *et al.* (1998) that total protein and albumin were affected by betaine, but the effects were dependent on the energy and crude protein level of the diet. Matthews *et al.* (1998) and Overland *et al.* (1999) reported no significant effect of supplementary betaine on serum or plasma cholesterol concentration. However, in later study, Matthews *et al.* (2001) and Martins *et al.* (2010) reported that betaine supplemented pigs presented higher serum cholesterol.

Based on the results of the present study it can be concluded that dietary betaine supplementation @ 3 g/kg throughout the length of gestation was helpful in decreasing cholesterol and triglyceride concentration in sows.

ACKNOWLEDGEMENTS

The authors are very much thankful to the Director, ICAR-Indian Veterinary Research Institute, Izatnagar for providing necessary facilities to carry out the research work in accordance with the regulations and recommendations of ICAR.

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Received on 10-04-2019 and accepted on 30-05-2019

Indian J. Anim. Nutr. 2019. 36 (2): 207-209
doi: 10.5958/2231-6744.2019.00034.3

Indian Journal of Animal Nutrition

SHORT COMMUNICATION

Replacement of Maize by other Cereals on Performance of Pratapdhan Chicks

C.M. Yadav*and H.L. Bugalia
Krishi Vigyan Kendra, Bhilwara, Maharana Pratap University of Agriculture and Technnology, Udaipur-313001, Rajasthan, India

ABSTRACT

An experiment was conducted to study the effect of replacing maize quantitatively at 50 per cent level with broken rice, bajra, jowar or barley in isocaloric and isonitrogenous ration on day-old Pratapdhan chicks. Two hundred and fifty day-old unsexed Pratapdhan chicks were randomly divided into 5 equal groups, each group was sub-divided in to five groups for 8 weeks. Significantly higher body weight and weight gain was observed in broken rice fed groups as compared to other treatments groups. Body weight and weight gain of maize, broken rice and bajra fed groups were significantly higher as compared to jowar and barley fed groups. The FCR at 8 weeks of age in different treatments ranged from 3.01 to 3.09 and differences were statistically non-significant. Apparent dry matter digestibility was 50.75, 54.44, 52.82, 51.15 and 52.44%, protein efficiency ratio was 1.27, 1.21,1.26 1.21 and 1.28, and efficiency of energy utilization was 9.56, 9.35, 9.25, 9.85 and 9.58 kcal/ g weight gain, in the five respective groups. Feed cost per unit gain of body weight was minimum (₹ 16.42) in T_2 groups. It was concluded that maize could be replaced with either broken rice, bajra or jowar at 50 percent level in the pratapdhan chick ration.

Key words: Broilers, Cereals, Feed conversion ratio, Growth, Maize

Maize is the principal energy source used in poultry diets in most of the countries because of its high-energy value, palatability, presence of pigments and essential fatty acids. Maize production in India was 27 million tonnes during 2017-18 (FICCI, 2017). Among cereals, maize has been recognised as the best feed ingredient in poultry diet, but its availability has always been limited and the cost of maize has gone very high in recent years. In order to reduce feed cost, it is desirable to explore the possibility and suitability of feeding other cereals *viz.*, bajra, jowar, rice and barely, which are available at relatively cheaper rate as compared to maize. Hence, the present study was planned to find out the effect of replacing maize by some other cereals *viz.*, bajra, broken rice, jowar or barley on performance of Pratapdhan chicks.

Freshly hatched, apparently healthy, 250 day-old, unsexed Pratapdhan chicks were randomly divided into 5 equal groups in an experiment based on completely randomized design. Each treatment groups had a replicate of 10 birds each. They were offered either maize based control diet (T_1) or one of the experimental diets. Maize was replaced quantitatively at 50 per cent level with either broken rice (T_2), bajra (T_3), jowar (T_4) or barley (T_5) for 8 weeks (Table 1). All the chicks were vaccinated against Ranikhet and Marek's diseases after hatching. The chicks were reared under uniform conditions of housing, lighting and other managemental practices.

A daily record of the feed consumption was maintained. The chicks were weighed individually at the start of experiment and subsequently at weekly intervals. The feed conversion ratio (FCR) was calculated by using the following formula –

$$\text{FCR} = \frac{\text{Total amount of feed consumed (g)}}{\text{Body weight gain (g)}}$$

$$\text{Performance index} = \frac{\text{Body weigh t gain (g)}}{\text{FCR}}$$

$$\text{PER} = \frac{\text{Weight gain (g)}}{\text{Protein consumed (g)}}$$

$$\text{Efficiency of energy utilization} = \frac{\text{Total ME intake (M cal)}}{\text{Body weight gain (g)}}$$

Two balance trial of three-day each were conducted to determine DM digestibility and efficiency

*Corresponding author:s E. mail:cmyadav_jaipur@yahoo.com

Table 1. Ingredient composition of experimental ration (kg/100 kg feed)

Ingredients	Starter Ration (0-6)					Finisher Ration (6-8 weeks)				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
Maize	46	23	23	23	23	56	28	28	28	28
Broken rice	-	23	-	-	-	-	28	-	-	-
Bajra	-	-	23	-	-	-	-	28	-	-
Jowar	-	-	-	23	-	-	-	-	28	-
Barley	-	-	-	-	23	-	-	-	-	28
Rice polish	16	11	14	12	13	15	9	14	13	12
Groundnut cake	31	34	28	30	29	24	27	22	24	25
Fish meal	5	4	7	7	7	3	2	3	2	2
Groundnut oil	-	3	3	3	3	-	4	3	3	3
Mineral mixture	2	2	2	2	2	2	2	2	2	2

*Vets A, B_2 $D_3$0.020; *T.M-50 0.010; *Neftin -200 0.050; *Amprol plus 0.050

of nitrogen and energy (ME) utilization, first one during last three days of the first month and the second one during last three days of the second month. During these periods, birds were transferred to metabolic cages. Samples of feed ingredients and formulated ration were analysed according to AOAC (2005). Samples of dropping were analysed for DM and protein. Data obtained were analyzed as per Snedecor and Cochran (1989).

The results indicated that the ration in which maize was replaced with broken rice at 50 per cent level gave significantly ($P < 0.05$) higher body weight and weight gain at 8 weeks of age as compared to other treatment group. Present results are in agreement with the findings of Rama Rao *et al.* (2004) who reported significant improvement in body weight gain in broilers fed pearl millet as the principal source of energy compared to those fed maize. Raju *et al.* (2004) reported no effect on body weight and feed consumption on total replacement of maize with sorghum, pearl millet and ragi along with enzyme supplementation in broilers up to 5 weeks of age.

Chauhan (1991) reported that substitution of paddy at 50 per cent level in place of maize in broiler ration resulted in significantly higher body weight gain at 6 and 8 weeks of age as compared to control of 100 per cent maize based ration. Prabhakar *et al.* (1989) also observed optimum growth when maize was replaced at 30 per cent level by damaged rice in broiler ration. It is revealed from the results that bajra could replace maize grain by 50 per cent level without affecting the body weight and weight gain in broiler. These results are in

Table 2. Treatment means for body weight (g/chick), body weight gain (g/chick) and feed consumption (g/chicks) during 0 to 8 weeks period

Treatment	Body weight (g/chick)	Body weight gain (g/chick)	Feed consumption (kg/d)
T_1	692^{c}	655^{c}	2.6
T_2	807^{d}	770^{d}	2.6
T_3	696^{cd}	659^{cd}	2.9
T_4	747^{a}	720^{a}	2.4
T_5	771^{b}	733^{b}	2.8
Pooled SE	21.3	21.4	0.2

[a,b,c]Figure with different superscripts with a column differ from each other significantly ($P<0.05$)

Table 3. Effect of dietary treatments on dry matter digestibility, protein efficiency ratio (PER) and efficiency of energy utilization in chicks

Treatments	DM digestibility (%)	Protein Efficiency Ratio	Efficiency of energy utilization kcal/g weight gain	Cost of feed per Unit (₹)
T_1	50.752	1.27	9.56	17.82
T_2	54.40	1.21	9.35	16.42
T_3	52.82	1.26	9.25	17.41
T_4	51.1	1.21	9.85	17.70
T_5	52.44	1.28	9.58	17.68

conformity with Satyanarayna Reddy *et al.* (1991).

The maximum feed consumption of 2806 g was observed for barley-based ration followed by bajra, broken rice, maize and jowar based ration. The higher feed consumption on barley-based ration may be due to its higher fiber content. Better feed efficiency in pearl millet fed birds than maize fed birds has also been recorded (Raju *et al.,* 2003). The replacement of maize at 50 per cent level by broken rice, bajra or jowar had no effect on feed conversion ratio (Table 2). Several earlier reports also indicated that performance of chicken fed bajra and jowar based diets were similar to those fed a maize based diet (Khot *et al.,* 1990; Satynarayana Reddy *et al.,* 1989). Replacement of maize by broken rice reduced the feed cost per kg weight gain (₹ 16.42) as compared to other treatments. Rama Rao *et al.,* (2002) reported that the feed cost was reduced by replacing the maize with pearl millet. Thus, it was concluded that maize could be replaced with either broken rice, bajra or jowar at 50 percent level in the ration of Pratapdhan chick.

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Received on 18-12-2018 and accepted on 22-04-2019

Indian J. Anim. Nutr. 2019. 36 (2): 210-214
doi: 10.5958/2231-6744.2019.00035.5

Indian Journal of Animal Nutrition

SHORT COMMUNICATION

Effect of Feeding Turmeric and Amla on Dressing Percentage and Meat Bone Ratio of Broilers

Gyan Chandra, S.H. Mane, S.A. Dhage and A.V. Rathor
Mahatma Phule Krishi Vidyapeeth Rahuri, College of Agriculture, Pune-411005, Maharashtra, India

ABSTRACT

An experiment was conducted to study the inclusion of turmeric, amla and their combinations on production performance, *viz.,* weight gain, feed intake, feed conversion ratio, dressing percentage and meat bone ratio for a period of six weeks with seventy commercial, straight run day-old Vencobb-400 broiler chicks. These chicks were randomly grouped into seven treatments with ten chicks each. The treatment groups consisted of a basal diet (control, T_0), supplemented with either 0.25% turmeric (T_1), 0.50% turmeric (T_2), 0.25% amla (T_3), 0.50% amla (T_4), 0.25% turmeric+amla (T_5) and 0.50% turmeric+amla (T_6). The weight of heart, liver and gizzard increased slightly with supplementation of turmeric and amla which were non-significant. The higher dressing percentage (72.20 %) and meat bone ratio (14.36%) were observed in T_6 on per cent live weight basis. The net profit was recorded in T_6 (54.74 ₹/bird) and T_5 (₹ 54.51/bird) as compared to other treatment groups.

Key words: Broilers, Cost, Dressing, Meat bone ratio, Mortality, Percentage

As a primary source of animal protein, the poultry sector offers a valuable repository to bridge the gap between demand and the availability of balanced nutrition. Poultry production, particularly broiler production, is the quickest way to increase the availability of high quality protein for human consumption. Since the feed cost alone contributes to about 70-75% of the total cost of production, economic poultry production is, therefore, possible only when the feed cost is reduced and efficiency of feed utilization is increased (Pervez *et al.* 2011). Therapeutic properties of turmeric include anti-oxidant, anti-diabetic, antibacterial, antifungal, antiprotozoal, antiviral and hypocholesteremic activities (Ahmadi, 2010). Turmeric supplementation has been reported to improve the body weight gain and feed consumption of broiler chicken. (Osawa *et al.,* 1995). Amla (*Embellica officinalis*) is one of the richest sources of vitamin C and vitamin E. A combination of these two could boost the performance of broiler chicken. Hence, this research work was designed in broilers by including different levels of turmeric, amla and their combinations to study the dressing percentage and meat bone ratio in broilers.

The present experiment entitled was carried out at poultry unit, Department of Animal Husbandry and Dairy Science, College of Agriculture, Pune. The experimental diet was formulated according to the standards prescribed in Bureau of Indian Standards (BIS, 1992). Seventy day-old commercial straight run broiler chicks of "Ven-cobb-400" strain were procured from Venkateshwara Hatchery, Pvt. Limited, Pune, Maharashtra. These chicks were randomly and equally distributed into seven treatment groups as T_0, T_1, T_2, T_3, T_4, T_5, and T_6, with 10 numbers of chicks in each group. The treatment groups consisted of a basal diet (control, T_0), supplemented with either 0.25% turmeric (T_1), 0.50% turmeric (T_2), 0.25% amla (T_3), 0.50% amla (T_4), 0.25% turmeric+amla (T_5) and 0.50% turmeric+amla (T_6). All experimental chicks were reared on deep litter system in pens up to 6 week of age. The standard managemental practices were provided to the experimental birds. All the broiler chicks were fed with ground maize for first two days of age. For the experiment, a commercial broiler pre-starter, starter and finisher crumbles was used. Pre-starter (0-2 wks), starter (3-4 wks) and finisher rations (5-6 wks) were used during experimental period of 6 wks. The diets was fed *ad-libitum* to experimental groups by adding required amount of turmeric and amla powder as per treatment. At the end of the trial, two birds per treatment group were randomly picked up and slaughtered as per the method of Arumugam and Panda

Table 1. Details of dietary treatments

Treatment	Composition of experimental diets
T_0	Basal diet (Control group)
T_1	Basal diet + turmeric powder @ 0.25%
T_2	Basal diet + turmeric powder @ 0.50%
T_3	Basal diet + amla powder @ 0.25%
T_4	Basal diet + amla powder @ 0.50%
T_5	Basal diet + turmeric and Amla powder @ 0.25%
T_6	Basal diet + turmeric and Amla powder @ 0.50%

(1970). The pre-slaughter live weight, eviscerated carcass weight, heart weight, liver weight and gizzard weight were recorded.

The highest heart weight (18.00 g) was obtained in group T_3 in which diets of the birds were supplemented with 0.25% amla, but difference was non-significant among other groups. The highest liver weight (50.00 g) was obtained in T_0 in which birds were fed basal diet, whereas, highest gizzard weight (98.00 g) was obtained in group T_6 in which supplementation of basal diet was done with 0.50% amla and turmeric powder. Carcass yield of different dietary treatments did not differ significantly among the group. However, the best feed efficiency ($P<0.01$) was noticed in 0.25% amla and turmeric powder and 0.50% combination groups compared to control group (Table-4). Dietary supplementation of turmeric and amla powder at both levels (0.25% and 0.50%) did not have any adverse effect on feed intake in broiler.

The effect of feeding turmeric and amla powder either alone or in combination on dressing percentage and meat bone ratio is presented in table 5. Significantly ($P<0.01$) higher dressing percentage was observed in T_6 (72.20 %) followed by T_5, T_3, T_2, T_1, T_4 and T_0 treatments. Durrani *et al.* (2006) reported higher dressing percentage, breast and giblet weight in broilers fed diet containing 0.5 percent turmeric. Similarly, Singh *et al.* (2007) also reported that supplementation of amla and turmeric powder (@ 5 g/kg of feed) in broiler diet improved dressing percentage in broilers. Higher meat bone ratio was observed in T_6 (14.36) which was statistically significant ($P<0.05$). Results indicated that dietary inclusion of turmeric and amla at the rate of 0.25% and 0.50% had significant positive effect in terms of dressing percentage and meat bone ratio in commercial broilers.

Results indicated that dietary addition of combination of turmeric and amla powder at the rate of

Table 2. Composition of pre-starter, starter and finisher feed

Ingredient	Pre-Starter	Starter	Finisher
Maize	51.95	63.25	62.45
Jowar	3.00	3.00	3.00
Bajra	7.00	0.00	4.05
Maize gluten	3.00	3.00	3.00
Meat cum bone meal	3.00	3.00	3.00
Rape seed DOC	1.00	0.00	1.00
Soybean DOC	28.06	24.9	20.06
Chicken meat meal	0.00	0.00	1.00
Lime stone powder	0.64	0.835	0.225
Di- calcium phosphate	0.595	0.455	0.68
Sodium bicarbonate	0.10	0.13	0.10
Free flow iodised salt	0.22	0.205	0.245
Broiler (Pre St./Strt./Finisher) premix	1.335	1.125	1.09
Choline chloride-60%	0.10	0.10	0.10
Total	100.00	100.00	100.00

Table 3. Effect of turmeric and amla (powder) on carcass traits in broilers (live weight basis in gram)

Treat.	Heart	Liver	Gizzard
T_0	16.00±2.00	50.00±1.00	81.00±2.00
T_1	14.00±0.00	42.00±2.00	86.00±6.00
T_2	14.00±1.00	40.00±1.00	92.00±3.00
T_3	18.00±1.00	46.00±2.00	92.00±1.00
T_4	16.00±0.00	44.00±2.00	86.00±4.00
T_5	16.00±1.00	42.00±2.00	96.00±2.00
T_6	14.00±01.00	48.00±3.00	98.00±2.00

Table 4. Effect of turmeric and amla (powder) on feed intake (g/bird) and FCR of broilers

Average weekly feed intake (g/bird)								
1st	147.80±2.11	149.65±1.10	149.45±1.05	146.60±2.41	147.10±1.71	149.35±1.13	145.60±1.76	NS
2nd	357.55±1.30	352.35±2.81	355.60±1.87	356.95±0.43	357.10±1.05	354.50±0.56	352.15±1.60	NS
3rd	654.15^{c}±1.23	636.75^{ab}±3.53	641.95^{b}±2.25	641.35^{ab}±3.01	634.80^{a}±0.99	650.00^{c}±1.03	651.80^{c}±1.40	6.61**
4th	853.95^{c}±1.92	852.20^{bc}±0.74	845.20^{a}±2.49	849.65^{abc}±1.02	851.70^{bc}±1.29	849.15^{ab}±1.06	845.15^{a}±1.92	4.72**
5th	1039.20^{b}±2.81	1028.35^{a}±2.55	1028.05^{a}±2.79	1037.00^{b}±0.66	1037.90^{b}±0.71	1036.85^{b}±1.64	1027.95^{a}±2.05	6.80**
6th	1162.40^{c}±1.22	1160.85^{c}±0.75	1155.45^{ab}±2.10	1152.50^{a}±1.81	1161.25^{c}±0.81	1159.90^{bc}±1.31	1152.30^{a}±1.98	4.62**
0 to 6th	4215.05±1.77	4180.15±1.91	4175.70±2.09	4184.05±1.56	4189.85±1.09	4199.75±1.12	4174.95±1.78	-
Average weekly FCR								
1st	0.97±0.01	0.95±0.00	0.94±0.00	0.94±0.01	0.95±0.01	0.97±0.00	0.94±0.01	NS
2nd	1.19±0.04	1.17±0.01	1.11±0.01	1.15±0.06	1.19±0.03	1.17±0.04	1.10±0.02	NS
3rd	1.38^{cd}±0.01	1.32^{bcd}±0.01	1.37^{cd}±0.02	1.38^{c}±0.03	1.30^{abc}±0.02	1.28^{ab}±0.04	1.24^{a}±0.02	0.07**
4th	1.62^{b}±0.04	1.42^{b}±0.04	1.38^{ab}±0.04	1.34^{ab}±0.04	1.30^{a}±0.05	1.30^{a}±0.03	1.36^{ab}±0.01	0.11**
5th	1.79^{b}±0.04	1.83^{b}±0.07	1.61^{a}±0.04	1.81^{b}±0.09	1.61^{a}±0.05	1.61^{a}±0.06	1.56^{a}±0.03	0.17**
6th	2.35^{c}±0.09	2.17^{abc}±0.08	2.28^{bc}±0.07	2.12^{ab}±0.10	2.11^{ab}±0.06	2.08^{ab}±0.05	1.97^{a}±0.05	0.21*
0 to 6th	1.55^{b}±0.04	1.48^{ab}±0.03	1.45^{ab}±0.03	1.46^{ab}±0.05	1.41^{a}±0.04	1.40^{a}±0.04	1.36^{a}±0.02	-

[a,b,c,d]Means bearing different superscripts in a row differ significantly (*P<0.05; **P<0.01)

Table 5. Effect of turmeric and amla (powder) on dressing percentage and meat bone ratio on live weight basis

Treat. / Parameter	Dressing percentage (%)	Meat bone ratio (%)
T_0 Basal diet (Control group)	65.81^{a}±1.38	13.35^{a}±0.02
T_1 Basal diet + turmeric powder @ 0.25%	67.55^{abc}±0.18	14.19^{b}±0.44
T_2 Basal diet + turmeric powder @ 0.50%	68.02^{bc}±0.10	14.35^{b}±0.06
T_3 Basal diet + amla powder @ 0.25%	68.93^{c}±0.96	13.28^{a}±0.06
T_4 Basal diet + amla powder @ 0.50%	66.71^{bc}±0.34	13.42^{a}±0.02
T_5 Basal diet + turmeric and Amla powder @ 0.25%	69.15^{c}±0.13	14.29^{b}±0.22
T_6 Basal diet + turmeric and Amla powder @ 0.50%	72.20^{d}±0.33	14.36^{b}±0.06
Significance	2.22**	0.64*

[a,b,c] Means bearing different superscripts in a column differ significantly (*P<0.05; **P<0.01)

Table 6. Economics of broiler production:

Sr. No.	Particulars	T_0	T_1	T_2	T_3	T_4	T_5	T_6
1.	Cost of day old chick (₹)	28.00	28.00	28.00	28.00	28.00	28.00	28.00
2.	Cost of feed (₹/kg)	27.00	27.00	27.00	27.00	27.00	27.00	27.00
3.	Cost of turmeric & amla (Powder) (₹/Kg of feed)	0.00	0.75	1.5	0.60	1.20	0.67	1.35
4.	Total cost of feed (₹/kg)	27.00	27.75	28.50	27.60	28.20	27.67	28.35
5.	Average total feed consumed per bird (kg)	4.215	4.180	4.175	4.190	4.194	4.200	4.175
6.	Cost of feed consumed per bird (₹) (4x5)	113.81	116.00	119.01	115.48	118.15	116.21	118.36
7.	Average body weight at the end of 6th week (kg)	2.595	2.708	2.763	2.776	2.858	2.896	2.930
8.	Feed consumption per kg live weight gain (kg)	1.62	1.54	1.51	1.51	1.47	1.45	1.42
9.	Cost of feed per kg live weight gain (₹)	43.84	42.84	43.07	41.59	41.34	40.13	40.40
10.	Rearing cost (vaccines, water, electricity, labour charge, *etc.*) per bird (₹)	4.00	4.00	4.00	4.00	4.00	4.00	4.00
11.	Total cost of production (₹) (1+6+10)	145.81	148.00	151.01	147.48	150.15	148.21	150.36
12.	Average price realized @ ₹ 70 per kg live weight (₹)	181.71	189.55	193.40	194.34	200.09	202.71	205.10
13.	Net profit per bird (₹) (12-11)	35.91	41.55	42.40	46.86	49.93	54.51	54.74
14.	Cost benefit ratio	1.25	1.28	1.28	1.32	1.33	1.37	1.36

0.50% had higher growth rate, dressing percentage and net profit.

ACKNOWLEDGEMENTS

The authors are thankful to Mahatma Phule Krishi Vidyapeeth Rahuri, College of Agriculture Pune, for the facilities and financial support provided to carry out this research work.

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Received on 01-12-2018 and accepted on 25-05-2019

Indian J. Anim. Nutr. 2019. 36 (2): 215-217
doi: 10.5958/2231-6744.2019.00036.7

Indian Journal of Animal Nutrition

SHORT COMMUNICATION

Supplementation of Microbial Feed on Performance of Growing Goats

C.M.Yadav* and N.R. Meena
Krishi Vigyan Kendra, Bhilwara, Rajasthan
Maharana Pratap University of Agriculture and Technology, Udaipur-313001, India

ABSTRACT

Thirty growing goats of similar age and body weight were selected from adopted village by Krishi Vigyan Kendra, Bhilwara, Rajasthan and divided into three groups of 10 animals each. One group (T_1) as control was maintained on farmer's practices. While T_2 was fed concentrate mixture @1.5% of the body weight and T_3 was fed same as in T_2 + microbial feed supplement @ 3 g/day/head for 120 days. The average body weight gain /day/head (g) was significantly ($P < 0.05$) higher in T_3 (82.3±0.1) as compared to T_2 (74.3±0.14) and T_1 (42.0±0.24) groups. The growth rate of growing goats improved significantly ($P < 0.05$) in microbial feed supplement fed group over control. Hence, it was concluded that feeding of microbial feed supplement along with balanced diet would improve growth performance in growing goats.

Key words: Daily weight gain, Growing goat, Microbial, Supplement

Microbial feed supplementations have shown promising results in a variety of animal production areas. The multispecies probiotic feeding increased average daily gain and feed efficiency in lambs (Lema *et al.,* 2001) and direct feed microbial supplementation also increased feed efficiency during the growing-finishing and finishing stages in pigs (Davis *et al.,* 2008). The use of microbial feed supplements containing *Saccharomyces cerevisiae*, has been found to improve the performance of lactating animals (Dobicki *et al.,* 2006). Supplementation with direct-fed microbials (DFM) has a beneficial effect on subsequent milk yields, fat and protein content of milk (Kritas *et al.,* 2006). Live microbial feed supplement, which beneficially affects the host animal by improving its intestinal microbial balance (Fuller, 1999) has been used to describe viable microbial cultures, culture extracts, enzyme preparations or various combinations of the above. The development and growth during this period has important bearing on its future productive and reproductive performance. The purpose behind the use of microbial feed supplement has been primarily to establish normal intestinal flora to prevent or minimize the disturbances caused by enteric pathogens and secondarily to serve the function of antibiotic feed additives because there has been so called public mood against the use of antibiotic feed additives in diet of animals. *S. cerevisiae* releases essential enzymes, vitamins and amino acids during digestion, all of which are thought to have a positive effect on the performance of ruminants (Waziry and Ibrahim, 2007). In ruminants the uses of microbial feed supplement have beneficial effect as growth promoter (Yirga, 2015). However, little research has been conducted on the use of microbial feed supplement on growth performance in goats under Indian conditions. Thus, an attempt was made to ascertain the effect of feeding microbial feed supplement in the ration on the performance of growing goats.

A feeding trial of 120 days was conducted on thirty growing goats of similar age and body weight (October, 2014 to February, 2015). All the experimental animals were maintained under loose housing and group management systems. The experimental animals were randomly divided into three groups of equal size (n=10) viz, T_1 farmers practices, natural grazing practice (6-8 hours), T_2 recommended practices as in T_1+ concentrate mixture @ 1.5 % of body weight and T_3 fed as in T_2 + microbial feed supplement containing *S. cerevisiae* 1.5 X 10^{11} colony forming unit (CFU), *Lactobacillus sporogenes* 50,000 million CFU and rich in calcium, phosphorus, protein, carbohydrates, vitamins

*Corresponding address: cmyadav_jaipur@yahoo.com

Table 1. Chemical composition of concentrate mixture (% DM basis)

Particular	Concentrate mixture
Dry Matter	90.83
Crude protein	18.22
Ether extract	2.03
Crude fibre	11.92
Nitrogen free extract	62.16
Acid insoluble ash.	5.67

*Chemical composition of concentrate mixture procured by Rajasthan Cooperative Dairy Federation Ltd., (Saras Dairy Bhilwara)

(@3gm/head/day). All the animals were fed individually. Clean and fresh drinking water was available throughout the experimental period. The body weight of animals was recorded fortnightly. Representative samples of feeds and fodders used for feeding of animals were collected at weekly interval throughout the experimental period and the samples were analysed for proximate principles (AOAC, 2005). The data were statistically analyzed by the procedures for completely randomized design (Snedecor and Cochran, 1994).

The chemical composition of concentrate mixture is given in Table 1. The animals in group T_3 were fed microbial feed supplementation containing *S. cerevisiae* 1.5 X 10^{11} CFU, *Lactobacillus sporogenes* 50000 million CFU (@ 3 g/head/day) along with T_2 diet. The average body weight gain /day/head (g) was significantly ($P < 0.05$) higher in T_3 (82.30±0.1) as compared to T_2 (74.26±0.14) and T_1 (42.00±0.24) (Table 2). The higher body weight gain in growing goat with combined microbial feeding may be due to maintenance of rumen pH and high buffering ability of *Lactobacillus* bacteria. The average weight gain and body weight gain in 120 days of growing goats in group receiving microbial feed supplement was significantly ($P<0.05$) higher in T_3 than the control (T_1) and group T_2. Similar results were reported in cattle (Rust *et al.,* 2000) and lamb (Lema *et al.,* 2001). Further incorporation of yeast (*S. cerevisiae*) tends to increase the number of cellulolytic bacteria in the rumen of animals fed high fibre diet with enhanced microbial crude protein synthesis (Tripathi and Karim, 2010). Therefore, prior animal health status and the timeline of administration may influence the effect of microbial supplementation.

Supplementation of microbial feed supplement resulted in increase in net return over control group (₹ 1680). The benefit cost ratio was higher (1.42) on feeding microbial feed supplement in group (T_3) as compared to1.30 in T_2 and 1.10 in control group (T_1). Net returns (Rs/animal/day) were higher in group T_3, T_2 and T_1 groups, respectively (Sharma Deka 2009).

Hence, it can be concluded that the feeding of microbial feed supplement in ration was found to be beneficial in terms of improvement in growth rate and higher net return in experimental growing goats as compared to farmer's practices.

ACKNOWLEDGMENTS

The authors are thankful to the Senior Scientist and Head, Krishi Vigyan Kendra, Bhilwara for providing necessary facilities in conducting the experiment.

Table 2. Average body weight gain and daily weight gain in growing goats

Parameter	T_1	T_2	T_3
Initial body weight (kg)	11.45±0.36	11.36±0.46	11.28±0.58
Final body weight (kg)	16.49^{b}±0.18	20.27^{a}±0.14	21.15^{a}±0.21
Body weight gain /day/head (g)	42.00^{b}±0.24	74.26^{a}±0.14	82.30^{a}±0.18
Total body weight gain in 120 day/head (kg)	5.04^{b}±0.16	8.91^{a}±0.24	9.87^{a}±0.26
Net Return (Profit) in ₹ / unit	1680/-	2530/-	2760/-
BC Ratio	1.10	1.30	1.42

^{a,b} Means in a row bearing different superscripts differed significantly ($P<0.05$)

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Received on 09-05-2019 and accepted on 07-06-2019

First Announcement

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Invitation

It is an immense pleasure for Animal Nutrition Society of India to cordially invite you in its XVIII Biennial Conference, 2019 (INCAN 2019) on the theme "Nutritional Strategies for Improving Farm Profitability and Clean Animal Production" being held at Kolkata during 17 to 19 December, 2019. Number of eminent Academicians, Scientists, Scholars, Students, Policy makers Industrialist, Entrepreneurs and Farmers are likely to attend the conference from India and abroad. A series of theme talks, technical sessions, and round tables will be delivered during the conference.

Abstract Submission

All the participants from India as well as abroad are requested to submit their abstract (in extended for-mat) not exceeding 800 words through website (**http://www.incan2019.com**). The abstract should be on original research work related to the above thematic areas for oral and poster presentation. The last date for abstract submission is **15th November, 2019**. Authors will be informed for the type of presentation (oral/post-er) shortly after submission.

Address for correspondence:

Dr. G P Mandal, Associate Professor
Organizing Secretary, INCAN 2019
Department of Animal Nutrition
WBUAFS, 37, K B Sarani, Kolkata-700 037 | Phone- +91-9051538887; +91-9474928241
Email: incan2019@gmail.com; gpmandal1@gmail.com

PERSONALIA

Dr. C. S. Prasad received the prestigious "Prof. Anjaneya Prasad Lifetime achievement Award for Animal Nutritionist of India"

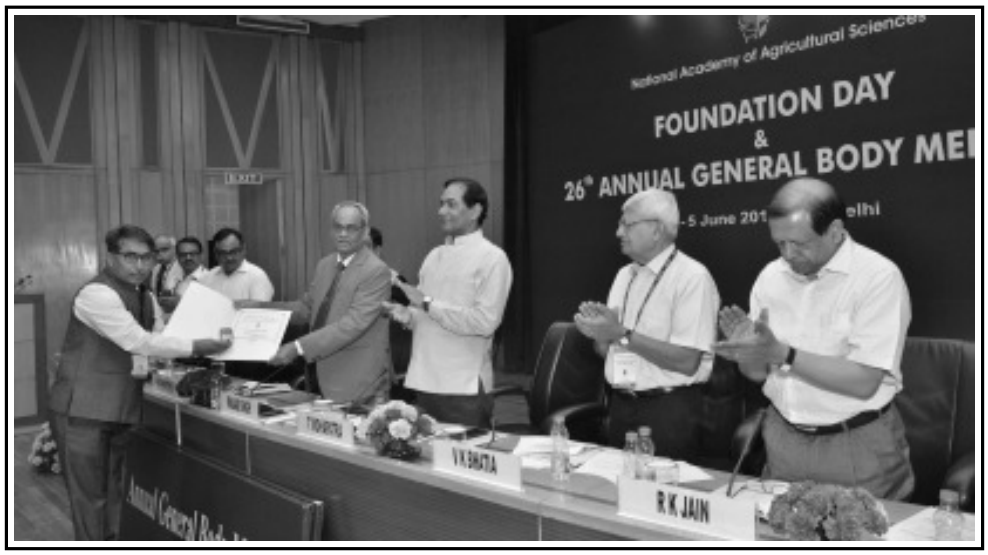
Dr. C S Prasad, Former Vice Chancellor, MAFSU, Nagpur, Director, NIANP, Bangalore and Assistant Director General (ANP), ICAR, New Delhi and former President of the society was conferred with the prestigious Prof. Anjaneya Prasad Lifetime achievement Award for Animal Nutritionist of India from the Hon'ble Vice Chancellor during the 8th convocation of SVVU, Tirupati held on 24th April 2019 at Tirupati. The award carries a cash prize and citation. He has contributed significantly in the area of Animal Nutrition, particularly in mineral nutrition, where he has developed Area specific mineral mixture based on the mineral status of water, soil, feed and biological materials in different agro-climatic zones of the country. This concept has been widely accepted by the livestock farmers and has helped in enhancing productivity in animals. His work on bypass protein requirement for cattle, improving the utilization of crop residues and strategic supplementation of limiting nutrients at farm-gate level has led to his receiving many prestigious awards and honors including the Inter-disciplinary ICAR Team Research Award thrice, CLFMA of India Lifetime achievement award among others. He is also the Fellow of National Academy of Agriculture Sciences. The ANSI congratulates Dr. Prasad for this great achievement and wishes him many more such laurels.

Dr. S.K. Bhatia received the prestigious Dr. P. Bhattacharya Award" of National Academy of Agricultural Sciences

Dr. Sudershan Kumar Bhatia, A world renowned Animal Nutritionist *par excellence*, Retired Professor CCS Haryana Agricultural University, Hissar was conferred with the prestigious "Dr. P. Bhattacharya Award" of National Academy of Agricultural Sciences. He received the award from the Hon'ble Union Minister of Agriculture and Farmers Welfare Sri Radha Mohan Singh Ji during the 14th Agricultural Science Congress, held during 20th to 23rd February, 2019 at New Delhi. The award comprised of citation, silver plaque and certificate. Dr. Bhatia, a Gold Medallist of HAU, has contributed immensely in the development of the science of Animal Nutrition in India. Some of His major contributions are in the area of rumen microbial diversity, cleaner animal production, differences in metabolism between cattle and buffalo, and measures to increase utilization of NPN substances in ruminant diets. His continued efforts that span over more than 37 years had resulted in many path-breaking technologies to reduce feed cost and to improve farm profitability and sustainability. His research contributions are duly recognized in the form many prestigious awards and honours; Rafi Ahmed Kidwai Memorial Award (1987), Outstanding Multi-disciplinary Team Research Award (1997) and Outstanding Teacher Award (2004) all of which were conferred by ICAR, and NAAS Recognition Award (200!) are only a few to name. Besides, he is the recipient of many prestigious fellowship like NAAS, distinctive Marie-Curie Fellowship by Commission of European Communities (CEC, Belgium) and DAAD (Germany). As an Expert he had rendered his valuable services to ICAR (Chairman of Consortium Advisory Committee for NAIP project, member QRT Team) NAAS, ASRB and Haryana Kisan Ayog. Dr. Bhatia's pursuits and accomplishments were not only well recognized in India (ICAR, NAAS, DST, UGC, CSIR) but also by International Organizations (CEC, Belgium, DAAD, Germany and USDA- USA). He has widely travelled and was involved in research and academic activities while working in in institutes and laboratories of USA, The Netherlands, UK, Germany, Czechoslovakia and Ethiopia. He has published 73 original research papers, 11 review articles, one book, one book chapter, 3 teaching manuals and 4 research bulletins, besides guiding many PG and Ph D as Major Advisor. The ANSI congratulates Dr. Bhatia for this great achievement and wishes him many more such laurels.

Dr. A.K. Tyagi received the prestigious "Vaisvik Industrial Research Award"

Dr. Amrish Kumar Tyagi, Principal Scientist and Head, Animal Nutrition Division, ICAR-National Dairy Research Institute, Karnal & President, Animal Nutrition Society of India was conferred with the prestigious "Vaisvik Industrial Research Award" of Vividhlaxi Aydogik Samsodhan Vikash Kendra, Mumbai. The award carried a cash prize of Rs 1.5 lacs and a citation. Dr. Tyagi, an eminent Scientist and Academician has contributed significantly in the area fatty acid metabolism, enrichment of ruminant animal products and development of species specific probiotic products. The ANSI congratulates Dr. Tyagi for this great accomplishment and wishes him all the best.



Dr. A.K. Tyagi admitted as Fellow, "National Academy of Agricultural Sciences"

Dr. Amrish Kumar Tyagi was admitted as a Fellow of National Academy of Agricultural Sciences (Fellow, NAAS) in its 26th Annual General Body Meeting held at New Delhi. Dr. Tyagi has made significant contribution in the area of ration balancing, strategic supplementation of the limiting nutrients, anionic mineral mixture for dairy cows, enhancement of conjugated linoleic acid in goat and buffalo milk and detoxification of glucosinolates in mustard cake and all of these technologies developed have helped in enhancing the income of the livestock farmers substantially. Heartiest congratulations to Dr. Tyagi and all the best for the future.

INDIAN JOURNAL OF ANIMAL NUTRITION
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June, 2019 **Vol. 36** **#2**

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Printed and published by Dr. Asit Das, Chief Editor, Indian Journal of Animal Nutrition, on behalf of Animal Nutrition Society of India at M.M. Printing Press, 202-L, Model Town, Karnal. M : 94160-72992