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Effect of Active Dry Yeast Supplementation on Nutrient Digestibility, Rumen Metabolites and Performances of Surti Goat Kids

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ABSTRACT

An experiment was conducted to ascertain the effect of active dry yeast (ADY) on the performances, nutrients digestibility and rumen metabolite profile in Surti goat kids. Sixteen male castrated Surti goat kids of average BW 7.53±0.08 (4-month-old) were randomly assigned to one of the two different groups with eight animals each. ADY (*Saccharomyces Cerevisiae* CNCM I-1077) was supplemented in one experimental group at the rate of 2 % of dry matter intake (DMI) (~ 10 g) for a period of 120 days including 6 days period of digestibility trial. At the end of the experiment, rumen liquor was collected from all animals 4 hours post feeding to assess for fermentation metabolites. There was a significant improvement (P<0.05) in final body weight, dry matter intake, feed to body weight gain ratio and digestibility of nutrients except ether extract in ADY supplemented group as compared to non-supplemented group. ADY supplementation significantly increased (P<0.05) the ruminal pH, TVFA and TCA precipitated nitrogen with a decreased concentration of ammonia and lactic acid in the ruminal fluid. It was concluded that supplementation of ADY (*S. Cerevisiae* CNCM I-1077) at 2% of DMI is beneficial in terms of performances, nutrient digestibility and rumen fermentation characteristics in Surti goat kids.

Key words: Active dry yeast, Digestibility, Goat, Performance, Rumen metabolites

INTRODUCTION

Goat has been playing an important role in livelihood of the rural people; providing income, employment, nutrition, supporting crop production and risk aversion in case of crop failure (Singh *et al.,* 2018). In India marginal and small farmers are the custodian of more than 76 % of the total goats in the country (GOI, 2018) with foraging as the major chunk of their feed resources. Conversely, tropical forages have some important limitation like higher amount of lignin, silica and cutin resulting in lower fermentation of structural carbohydrate that leads to their poor ruminal digestion and prolonged retention time; affecting the intake by the animals (Bello and Escboar, 1997). However, Considerable scope exist for manipulation of ruminal fermentation to improve the utilization of forages particularly in tropical as well as developing countries to maximize the productivity of goats by using available feed resources (Das and Ghosh, 2001; Das and Ghosh, 2007). In recent years, use of probiotic has been used to manipulate the rumen microbial ecosystem to enhance the nutritive value and utilization efficiency of low-quality roughages (Tang *et al*, 2008). Among the different microbial feed additives, *Saccharomyces cerevisiae* and *Aspergillus oryzae* are more effective in rumen, whereas lactobacilli are effective during pre-ruminant stage (Khuntia and Chaudhary 2002; Singh *et al.,* 2021). Yeast culture supplementation in ruminant diets can increase dry matter intake, production performance, cellulose degradation, and nutrient digestibility (Lesmeister *et al.,* 2004). However, there are variable yeast products, active dry yeast, wet yeast, cream and killed dry yeast (Vyas *et al.,* 2014). Active dry yeast (ADY) consists of pure dried yeast cells with viability counts ranging from 15-25 billion live yeasts cells or colony forming units (CFU) per gram (Stone, 1998). The yeast cultures are complex fermented products containing yeast and the metabolic products produced by the yeast fermentation that provide undefined fermentation factors which were recognized

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to simulate bacteria in the digestive tract (Stone, 1998). However, the responses of yeast supplementation were variable possibly due to the strain of yeast and differences in cell viability during production, storage, and delivery of different yeast products (Sullivan and Bradford, 2011; Vyas *et al.,* 2014). Furthermore, several studies have demonstrated that not all yeast strains are equally capable of stimulating ruminal bacteria, only 7 strains of over 50 strains tested had the ability to stimulate the growth and multiplication of fiber digesting bacteria in the rumen (Widmeier *et al.,* 1987; Dawson *et al.,* 1990; Dawson *et al.,* 1990; Kumar et. al., 1997; Saha *et al.,* 1999). Further it was apparent that few strains of yeast have the ability to stimulate both the beneficial bacteria and the bacteria associated with lactate utilization (Newbold *et al.,* 1996). Convincingly, supplementation of yeast in diets of ruminants had conflicting results (Wang *et al.,* 2016) which might be due to differences in diet composition, forage to concentrate ratio, type of forage feed, yeast dose, feeding strategy and more predominantly the form and strain of yeast (Yalcin *et al.,* 2011; Newbold *et al.,* 1996; Arcos-Garcia *et al.,* 2000). Therefore, the present study was undertaken to assess the effect of live ADY (*Saccharomyces cerevisiae* CNCM I-1077) supplementation on growth performance, nutrient utilization and rumen metabolites profile in Surti goat kids.

MATERIALS AND METHODS

The experiment was conducted at Livestock Research Station, Navsari Agricultural University, Navsari. Sixteen male castrated Surti goat kids of average body weight (BW) of 7.53±0.08 kg (~ 4-month-old) were selected for this experiment. The animals were housed in individual pens (1m × 2 m). In the first day, all kids were dewormed with albendazole (10 mg/kg BW). The pens were cleaned and disinfected by normal disinfectant before the onset of the experiment. The animals were randomly assigned to one of the two different groups, each with eight animals. ADY consisted of pure dried yeast cells (*S. Cerevisiae* CNCM I-1077) with viability counts ranging from 15-20 billion live yeasts cells (CFU) per gram, was procured from Lallemand Animal Nutrition, France. ADY (*S. Cerevisiae* CNCM I-1077) was supplemented in one of the experimental group at the rate of 2 % of DMI (~10 g) and the second group without any supplementation was control.

All the animals were offered concentrate mixture with leguminous hay and green as the basal diet to meet their nutrient requirements as per ICAR (2013). The concentrate mixture consisted of maize (30%), soybean meal (30%), wheat bran (37%), mineral mixture (2%) and common salt (1%). Weighed amount of concentrate mixture was provided to individual animals at 9.30 AM daily. Leguminous hay and green fodder were provided *ad libitum* after complete consumption of concentrate mixture. The animals had free access to clean drinking water. Standard management practices were followed under uniform conditions. The experimental feeding lasted for 120 days including 6 days period of digestibility trial during 91-96 d. During this period animals were shifted to the individual cages (1 m x 0.5m x 0.5m) having facilities of individual feeding and faeces collection. Weighed amount of feeds were offered and residues, if any, was collected daily in the morning. The representative samples of feeds offered and residues were collected, sampled, and analyzed daily for their dry matter (DM) content. The pooled and dried feed and residue samples were stored in airtight containers for further chemical analysis.

Total faeces voided by individual animals during the preceding 24 hours period were collected into a pre-weighed bucket, and weighed at a fixed time (9.00 AM) daily. The representative samples of faeces were collected for further sampling after proper mixing. Suitable aliquots of faeces were taken for DM estimation. Dried faecal samples of the six days were pooled and stored in LDPE bags for chemical analysis. For estimation of nitrogen, suitable aliquots of faeces were collected daily in glass bottles containing 20% H_2SO_4. Pooled samples of 6 days collection were then processed for further analysis. Feed, residues and faecal samples were analyzed for proximate principles (AOAC, 2000) and fibre fractions (Van Soest *et al.,* 1991).

At the end of the experimental period, rumen liquor was collected from all animals 4 hours post feeding through the stomach tube and was assessed for its metabolites *viz.* lactic acid, total volatile fatty acids (TVFA) and their fractions and nitrogen fractions.
The pH of rumen liquor was recorded by immersing the combined glass electrode of a digital pH meter into 50 ml of sample. The rumen liquor samples were analyzed for ammonia nitrogen as per Weatherburn (1967). Total nitrogen and tri-chloro acetate (TCA) precipitatable nitrogen were estimated by micro- Kjeldahl method as described by AOAC (2000). Non-protein nitrogen (NPN) was calculated as the difference between total nitrogen and TCA precipitatable nitrogen of rumen liquor. Rumen liquor samples were prepared by adding 0.2 ml of 25% metaphosphoric acid per ml of rumen liquor, allowing it to stand for 2 h followed by cryo-centrifugation at 5000 rpm for 20 min. Supernatant was used for estimation of volatile fatty acids (VFA). Estimation of VFA was done using Nucon-5765 Gas Chromatograph (AIMIL, New Delhi, India) equipped with a double flame ionization detector as per method described by Cottyn and Boucque (1968). Lactic acid concentration in the rumen liquor was estimated as per the method described by Barker and Summerson (1941). Data were statistically analyzed by paired 't' test with SYSTAT 7.0 (1997) and significance was declared at $P<0.05$.

RESULTS AND DISCUSSION

The chemical composition and fibre fractions of concentrate, green maize and leguminous hay were within the normal range (Table 1) with respect to different nutrients and fibre fractions (Ranjhan 1991). A significantly increased ($P<0.05$) final body weight and average daily gain (ADG), average daily dry matter intake (DMI) along with an improvement ($P<0.05$) in feed conversion efficiency (FCE) were observed in yeast supplemented group (Table. 2). Supplementation of yeast to the animal feed improved it's palatability as the glutamic acid produced by the yeast cell improved the taste of the feed (Agarwal, 2002). Another plausible reason for higher DMI in the ADY supplemented group may be the elevated ruminal pH (Table 3) as low ruminal pH can negatively affect fiber degradation and DMI (Chaucheyras-Durand *et al.,* 2008). In the present study, the increased DMI might be responsible for an improvement in final body weight, ADG and FCE in the yeast supplemented group. Robinson and Erasmus (2009) reported that dietary supplementation of yeast culture has a positive effect on feed intake, which ultimately enhances the growth performance of the animals. Several previous studies reported an increase in dry matter (DM) intake and milk production in dairy animals supplemented with active dry yeast (EI-Ghani, 2004; Jouany, 2006; Stella *et al.,* 2007). Also, the improvement in performance indices (ADG, final weight, DMI, FCE) were reported in beef cattle or young ruminants by ADY supplementation (Lesmeister *et al.,* 2004; Galvao *et al.,* 2005).

The data pertaining to the rumen metabolites

Table 1. Proximate analysis of the feed offered (% dry matter)

Particulars	Concentrate	Green fodder	Dry fodder
Organic matter	94.2	89.85	86.78
Crude protein	17.84	7.14	7.58
Ether extract	2.92	3.32	1.67
Total carbohydrate	73.44	79.39	77.53
Neutral detergent fibre	23.24	49.13	54.88
Acid detergent fibre	14.85	31.46	37.56
Hemi cellulose	8.39	17.67	17.32.
Total ash	5.8	10.15	13.22

Table 2. Effect of active dried yeast (Saccharomyces cerevisiae CNCM I-1077) supplementation on performances in Surti goat kids

Parameters	Control	Supplemented group	P-value
Initial BW, kg	7.58±0.13	7.49±0.10	0.634
Final BW, kg	14.98±0.15	16.25±0.35	0.005
Gain in BW, kg	7.40±0.21	8.76±0.44	0.016
Average daily gain in BW, g	61.66±1.79	73.00±3.71	0.015
DMI (g/d/animal)	538.92±15.59	591.89±18.01	0.043
DMI % of BW	4.00±0.11	4.09±0.07	0.519
DMI % of $BW^{0.75}$	7.67±0.21	7.98±0.16	0.264
Feed: gain in BW	8.74±0.13	8.17±0.21	0.039

BW, body weight; DMI, dry matter intake, Values in row are significant at P<0.05.

profile are presented in Table 3. Supplementation of ADY had a significant effect (P<0.05). The increased pH in ADY supplemented group might be due to the decreased concentration of lactic acid (Table 3) because of the low dissociative constant (p*K*a) of lactic acid (3.7) as compared to the that of major VFAs (p*K*a is 4.8–4.9 for acetate, propionate and butyrate) which plays an important role in upholding the ruminal pH (Chaucheyras-Durand *et al.,* 2008). A decreased lactate concentration was reported in an *in vitro* incubations of yeast with mixed ruminal micro-organisms (Lynch and Martin, 2002; Lila *et al.,* 2004), which could be due to interactions between yeast cells and lactate metabolising bacteria. Another *in vitro* study showed that certain strain of *S. Cerevisiae* was able to outnumber *Streptococcus bovis*, competing for the utilization of sugars, which consequently limited the amount of lactate produced by this bacterial species and this effect was evident when yeast cells were alive, but was lost when heat-inactivated cells were used (Chaucheyras *et al.,* 1996). Moreover, several studies reported an enhanced growth and metabolism of

Table 3. Effect of active dried yeast (Saccharomyces cerevisiae CNCM I-1077) supplementation on rumen metabolites profile in Surti goat kids

Parameters	Control	Supplemented group	P-value
pH	6.56±0.02	6.66±0.03	0.011
NH3- nitrogen(mg/dl)	20.92±0.10	18.27±0.06	0.035
TCA-precipitated N (mg/dl)	93.38±1.58	98.12±1.52	0.048
NPN (mg/dl)	61.77±2.10	66.11±1.78	0.155
Total nitrogen (mg/dl)	155.15±2.84	164.24±1.98	0.029
Acetate (mmol/dl)	4.76±0.13	5.35±0.15	0.012
Propionate (mmol/dl)	1.91±0.11	2.28±0.13	0.031
Butyrate (mmol/dl)	1.20±0.05	1.19±0.03	0.931
TVFA (mmol/dl)	7.86±0.22	8.83±0.25	0.013
Lactic Acid (µmole/dl)	5.73±0.17	4.61±0.11	0.026
Acetate	60.65±0.55	60.62±0.88	0.982
Propionate	24.21±1.10	25.75±0.66	0.257
Butyrate	15.15±0.22	13.59±0.67	0.055
A/P ratio	2.55±0.15	2.36±0.07	0.299

NPN, non-protein nitrogen; TVFA, total volatile fatty acids; A/P ratio, acetate to propionate ratio; Values in row are significant at P<0.05.

Table 4. Effect of active dried yeast (Saccharomyces cerevisiae CNCM I-1077) supplementation on nutrient digestibility in Surti goat kids

Parameters	Control	Supplemented group	P-value
Dry matter	62.30±0.36	63.86±0.53	0.029
Organic matter	63.92±0.31	65.60±0.52	0.018
Crude protein	70.28±0.36	71.62±0.28	0.011
Ether extract	71.80±0.68	72.70±0.52	0.317
Total carbohydrate	61.76±0.48	63.60±0.47	0.016
Neutral detergent Fiber	49.08±0.39	50.96±0.73	0.046
Acid detergent Fiber	34.46±0.64	37.19±0.79	0.019
Hemi-cellulose	55.39±0.58	58.66±0.89	0.009

Values in row are significant at P<0.05.

lactate utilizing bacteria like *Megasphaera elsdenii* or *Selenomonas ruminantium*, in the presence of various live yeasts (Nisbet and Martin, 1991; Chaucheyras *et al.,* 1996; Newbold *et al.,* 1998). However, effects of ADY on ruminal pH have been inconsistent amongst studies probably due to differences in the basal diets (Beauchemin *et al.,* 2003) or to the strain of yeast used (Chung *et al.,* 2011). Supplementation of ADY significantly (P<0.05) decreased the rumen ammonia nitrogen with an increased TCA precipitated nitrogen fraction in the rumen liquor. Supplementation of yeast increased the total ruminal microbial population, particularly the cellulolytic bacteria (Santra and Karim, 2003) that may explain the decreased ammonia and increased microbial protein i.e TCA precipitated nitrogen fraction in the rumen liquor. Mosoni *et al.,* (2007) reported a two- to four folds increase in the number of 16S rRNA gene copies of cellulolytic bacteria *i.e., Rminococcus albus* and *Rminococcus. flavefaciens* measured with real-time PCR in rumen contents of sheep supplemented with ADY, and ammonia is the most preferred source of nitrogen for these rumen bacteria for their protein synthesis (Bryant and Robinson, 1963). In agreement to our result several earlier studies demonstrated a decreased ruminal ammonia and higher microbial protein fraction due to yeast supplementation (Harrison *et al.,*1988; Erasmus *et al.,* 1992; Dutta *et al.,* 2001; Kamra *et al.,* 2002).

Data pertaining to the digestibility of nutrients are presented in Table 4. Live yeasts have influenced growth and activity of fibre-degrading microorganisms in the rumen (Chaucheyras-Durand *et al.,* 2008) and stimulated the germination of zoospores from a rumen fungal strain of *Neocallimastix frontalis* (Chaucheyras *et al.,* 1995). In the present study, the quantification of rumen microbes was not done but the ruminal condition like less acidic pH, higher TCA precipitated nitrogen and lower ruminal ammonia (Table 3) indicted the possible increase ruminal microbial population as evident from the more volatile fatty acid fraction in the ruminal fluid. Further, decreased concentration of lactic acid indicated that the lactate being metabolized to propionic acid by the lactate utilizing bacteria (Prabhu *et al.,* 2012) which resulted in a significant increase in propionic acid concentration in the ruminal fluid. Several earlier studies demonstrated an increased rumen VFA production in various ruminant model when the basal diet was supplemented with either ADY or yeast culture (EI-Ghani, 2004; Chaucheyras-Durand *et al.,* 2008; Kamal *et al.,* 2013). The higher digestibility of nutrient like protein and fibre fraction (neutral and acid detergent fibre) in the present study (Table. 4) could be attributed to the elevated ruminal pH (Table 3) that plays an important role in regulating the population and activity of fiber degrading communities (Russell and Wilson, 1996; Chaucheyras-Durand *et al.,* 2008). Corroborating to our result, Williams *et al.* (1991) reported that elevated ruminal pH increased the population of fiber degrading bacteria following an improvement in forage digestion in dairy animals.

CONCLUSIONS

It is concluded that supplementation of active dry yeast (*Saccharomyces cerevisiae* CNCM I-1077) at 2% of DMI is beneficial in terms of gain in body weight, feed conversion efficiency, nutrient digestibility and improvement in rumen fermentation characteristics in Surti goat kids.

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