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GROWTH, CARCASS TRAITS AND GAS PRODUCTION IN NELLORE SHEEP FED COMPLETE DIETS SUPPLEMENTED WITH THERMOTOLERANT PROBIOTIC YEAST*

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ABSTRACT

A complete diet was formulated and supplemented with three levels of thermotolerant yeast-Saccharomyces cerevisiae (0 g/kg-control (CON); 1 g/kg (TPY_1); 2 g/kg (TPY_2) and 3 g/kg (TPY_3) to determine the appropriate level for inclusion in sheep diet by *in vitro* gas production (IVGP) technique. Eighteen Nellore ram lambs (12.33 ± 0.08 kg initial body weight, aged 3 months) were assigned randomly in the 180 days experiment to one of three groups to see the effect on intake, growth, feed conversion and carcass traits. Treatment diets were no yeast (CON; n = 6), with 1 g/kg mesophilic yeast strain-MTCC-1813 (MPY_1; n = 6) and with 1 g/kg thermotolerant yeast strain-OBV-9 (TPY_1; n = 6). There was significantly (P<0.01) higher IVGP, *in vitro* organic matter degradability, metabolizable energy and total degradable organic matter on rations TPY_1, TPY_2 and TPY_3 compared to CON diet. Partitioning factor and efficiency of microbial biomass production were higher (P<0.05) on rations TPY_1 and TPY_2 and higher (P<0.01) microbial biomass production on rations TPY_1, TPY_2 and TPY_3 compared to CON were recorded. Dry matter intake (DMI), DMI (% b. wt.) and DMI/kg$W^{0.75}$ were higher (P<0.01) in TPY_1 group than CON and MPY_1 groups, while intake of organic matter and crude protein was similar in all the groups. Intake of neutral detergent fibre and acid detergent fibre was higher (P<0.01) in lambs fed TPY_1 diet than CON and MPY_1 diets. The final body weight, total gain and average daily gain were higher (P<0.01) on TPY_1 followed by MPY_1 compared to CON group. Lambs receiving TPY_1 and MPY_1 diets had better (P<0.05) feed conversion ratio and cost of gain than CON diet. The test diets did not affect dressing percentage, though there was a higher (P<0.01) carcass weight compared to CON diet. No differences were also observed between test diets (TPY_1 and MPY_1) for per cent proportions of carcass cuts, except proportions of leg (higher (P<0.05) in TPY_1 group) and test diets (TPY_1 and MPY_1) not affected proportions of lean, bone and fat and bone to meat ratios but significantly higher (P<0.01) per cent weights of edible components and lower (P<0.01) per cent weights of non edible components were recorded in both test diets. The study concludes that, diets supplemented with 1 g/kg thermotolerant yeast improved the performance and certain carcass characteristics of Nellore ram lambs in comparison with mesophilic yeast, while being cost effective.

Keywords: Carcass traits; Feed conversion; Growth; In vitro gas production; Nellore ram lambs; Thermotolerant yeast.

In vitro gas production (IVGP) technique was extensively used by several authors as a tool to prove the potential in evaluation of efficiency of microbial biomass production (EMBP) from ruminant feeds[20]. A number of studies reported beneficial influence of yeast supplementation on the meat performance traits including body weight, daily gains and growth rate[21]. But the yeast used

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so far, was mesophilic in nature and may not exert more beneficial action due to the harsh environmental (temperature, variation in pH and bile concentration) conditions under which they have to survive. It was reported[16] that, high temperature in the gut of animals makes the limitation of using mesophilic yeast as probiotic. Thermo, acid, bile and osmo tolerant yeast (S. cerevisiae, OBV-9) was isolated[4], which grows at >42°C temperature, pH 2, 2% Ox bile and 30% sugars, that can be used as a feed additive in livestock for better productivity as reported[4].

Therefore, a complete diet was formulated and supplemented with three levels of thermotolerant yeast with an objective to determine the appropriate level for inclusion in sheep diets by in vitro gas production technique and an attempt was made to know the effect of dietary supplementation of thermotolerant yeast, in comparison with mesophilic yeast to see the intake, growth, feed conversion and carcass traits in Nellore ram lambs.

MATERIALS AND METHODS

Experiments were conducted at the Livestock Experimental Station of Sri Venkateswara Veterinary University, Hyderabad and the study area was known as Deccan plateau in southern part of India, at latitude 17°20′ N, longitude 78°30′ E and elevation of 536 m above sea level.

In vitro gas production (IVGP) profiles

IVGP technique[14,20] was used to describe the extent of gas production from treatment diets. Partitioning factor (PF) is calculated[7] as the ratio of substrate truly degraded to gas volume produced and the EMBP of test diets was determined by measuring the ratio of truly degradable organic matter (TDOM) and gas production as described[6]. The test diets (Table 1) were complete diets with roughage to concentrate ratio of 50:50 and processed into mash, supplemented with three levels of thermotolerant yeast-Saccharomyces cerevisiae (0 g/kg-control (CON); 1 g/kg (TPY_1); 2 g/kg (TPY_2) and 3 g/kg (TPY_3).

Animals, diets and management

Eighteen Nellore ram lambs (12.33 ± 0.08 kg initial body weight, aged 3 months) procured from farmers of Hyderabad, born in rainy season of 2008 were assigned randomly in the 180 days experiment, to one of three treatment diets (6 ram lambs/treatment diet). The dietary treatments were adlibitum, no yeast (CON; n = 6), with 1 g/kg mesophilic yeast-MTCC-1813 (MPY_1; n = 6) and with 1 g/kg thermotolerant yeast-OBV-9 (TPY_1; n = 6), formulated to have 12% CP (DM basis) to meet requirements of male lambs as recommended[12]. The yeasts (5 x 10^8 cfu/g) obtained from Department of Biotechnology (DBT) project, Hyderabad was used in the present study. All lamb groups were kept separately under hygienic conditions in well ventilated pens (4 m x 3 m) and were not allowed for grazing. All animals were injected with ivermectin (Ivectin 1%) for treatment and control of gastro-intestinal and ecto-parasites. Diets (CON, MPY_1 and TPY_1) were offered to the animals, on individual basis, twice a day (two equal meals at 09:00 and 15:00 h) with free access to clean, fresh and wholesome drinking water. Both thermotolerant and mesophilic yeasts (separately), mineral mixture and vitamin supplement were prepared into a premix and added into horizontal mixer directly. Molasses was heated to 70°C in the preheating chamber and then added into the mixer directly and were sampled upon mixing to ensure consistency in their chemical composition (Table 1). Daily weights of feeds offered and daily feed refusals were recorded to derive daily feed intake and DM intake.

Body weight measurements and slaughter procedures

All animals were weighed weekly during the experimental period. At the end of the growth trial, the final body weight (BW) of each animal was obtained by averaging live weights recorded for two consecutive days. Average daily gain (ADG, g) was calculated as the (final BW (g)– initial BW (g))/ number of days on trial. Feed conversion ratio (FCR) was calculated as the amount of feed consumed (kg DM) per body weight gain (kg).

At the end of the feeding trial, feed was withheld overnight and the animals were weighed to record fasting body weight (FBW). The animals were then slaughtered following standard procedures as described[9]. After slaughter, the head was removed at the atlanto-occipital joint and fore and hind feet removed at the carpus-metacarpal and tarsus-metatarsal joints, respectively as prescribed[10]. Hot carcass weights (HCW) were recorded immediately after slaughter, and then the carcasses were split into two halves through the median plane using a hand saw. Carcasses were cut into five parts (leg, loin, rack, shoulder & neck and fore shank & brisket) as suggested[8]. Leg was taken off from the carcass by cutting with a saw at right angle to back close to the hip bone. The loin was removed from the carcass from the hip bone to the anterior part of the last rib. The rack was obtained by cutting from the posterior part of the 12th rib to the anterior part of the 5th rib. Shoulder and Neck was carved by cutting from the posterior part of the 4th rib to the neck (including the neck). Before cutting the shoulder and the rack, an incision was made with a knife 4^2 above the costa-sternal joint and the foreshank and brisket part was removed with a saw.

Among non-carcass components, edible components which included heart, liver, testes, diaphragm, kidney and spleen and non-edible components which included skin, head, feet, blood, lungs, trachea, kidney fat, stomach and intestines were weighed and recorded. The weights of fat, muscle and bone were recorded separately from the carcasses. The dressing percentage was expressed as HCW x 100/FBW.

Chemical analyses of feed samples

Samples of feeds used in *in vitro* and dietary treatments were dried (70^{0}C), ground (1 mm screen) and stored for subsequent analyses of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF). DM and N were determined according to the official methods[3] and NDF and ADF as suggested[30].

In vitro gas production at 24 h, corrected for blank and standards, was used for estimation of in vitro organic matter degradability (IVOMD) and ME as suggested[14].

IVOMD (mg) = Gv X 2.20 and

ME (MJ/kg DM) = 2.2 + 0.136 x Gv + 0.0057 X CPDM/kg

Where, Gv is net gas production (ml/200 mg DM); CPDM/kg is crude protein multiplied by 10.

Statistical analysis

Data were analysed using the GLM procedures[28]. In all analyses, when least squares means were different at $P<0.05$, they were separated by the PDIFF option of SAS.

RESULTS AND DISCUSSION

In vitro gas production profiles

There was a higher ($P<0.01$) IVGP, IVOMD, ME and TDOM for test diets (TPY_1, TPY_2 and TPY_3) compared to CON diet and there was no difference among diets with theromotolerant yeast (Table 2). These results might be due to the addition of yeast and the suppressing effect of high cell wall present in the feeds resulting in decreased attachment of ruminal microbes to feed particles as reported[24]. The results of current study were in agreement with the findings of[32], who reported total gas was increased with the supplementation of S. cerevisiae that might have resulted from the increased production of propionate, because carbon dioxide is produced when propionate is made by some ruminal bacteria via the succinate to propionate pathway. Gas production is basically the result of fermentation of carbohydrates to acetate, propionate and butyrate and gas production from protein fermentation is relatively small as compared to carbohydrate fermentation[18]. Higher IVGP, IVOMD, ME and TDOM obtained for the test diets TPY_2 and TPY_3, indicating a better nutrient availability for rumen microorganisms as reported[19]. IVOMD values recorded were higher than the in vivo OMD values of the present study, possibly due to differences in rumen fluid content in which the test feeds were incubated.

Similarly, higher ($P<0.05$) PF and EMBP for diets TPY_1 and TPY_2 and higher ($P<0.01$) microbial biomass production (MBP) for diets TPY_1, TPY_2 and TPY_3 compared to CON were recorded in the current study. There was no difference for PF, MBP and EMBP among diets that contain varied levels of theromotolerant yeast. Significantly ($P<0.01$) higher in vivo DM intake, recorded for the diets having higher PF in the present study, is consistent with the reports of several researchers[5,29], who defined PF as an index of the distribution of truly degraded substrate between microbial biomass and fermentation waste products. When less gas is produced per unit weight of substrate truly degraded, proportionately more substrate is converted into microbial biomass, which means that, a higher PF would reflect higher conversion of truly degraded substrate into microbial biomass and vice versa. In the current study, the diets having higher IVGP volumes were having a low MBP value, showing an inverse relationship between IVGP and MBP. The average efficiency of microbial biomass production (EMBP, g/kg) obtained in the present study indicated, different contents of fermentable carbohydrates and available nitrogen to the rumen microbes.

Growth, feed intake, yield of carcasses and non-carcass components

Growth and feed intake

There was a slight increase in NDF content from 547 to 565.5 g/kg DM and ADF from 346.3 to 366.3 g/kg DM. The improvement in CP, NDF and ADF content by yeast inclusion with sorghum straw based test diets in the present study might be due to differences in treatment conditions and initial straw quality. Dry matter intake (g/day or g/kg $W^{0.75}$/day) was higher ($P<0.01$) in lambs fed TPY_1 ration than those fed CON and MPY_1 rations, while intake of OM and CP was similar among all the groups (Table 3). Higher DMI in sheep fed TPY_1 ration than those fed CON and MPY_1 rations is presumably attributed to the yeasts, which might have increased rate and extent of fibre digestion in the rumen. Intake of NDF and ADF was higher ($P<0.01$) in lambs fed TPY_1 diet compared to those fed CON and MPY_1 diets. The results were consistent with the findings of[27], who reported sheep diets supplemented with yeast significantly ($P<0.05$) improved voluntary feed intake. Several workers[1,31] also reported higher DMI on yeast supplemented diets in sheep and thus the findings of present investigation corroborate with their results.

Average initial BW at the beginning of the study was similar among test groups. The final

BW, total gain and ADG were higher ($P<0.01$) in lambs fed TPY_1 diet followed by MPY_1 compared to CON diet. Lambs receiving TPY_1 and MPY_1 diets had superior ($P<0.05$) FCR and cost/kg gain than those fed CON diet. These results were in accordance with the findings of[2,21] in lambs fed yeast supplemented diets. Higher nutrient intake along with efficient utilization of absorbed nitrogen on rations MPY_1 and TPY_1 might be attributable for increased ADG as reported[17,21]. In addition, the increase in ME of diets as a result of yeast supplementation may explain the higher weight gains recorded in sheep fed sorghum straw-based complete diets. Nellore lambs fed MPY_1 and TPY_1 diets had superior FCR than those fed CON diet. FCR values ranged between 10.34 and 12.51 in test rations. Consistent with the current study, the other workers[2,11] found superior FCR when sheep fed yeast supplemented diets. Cost of feeding was lower for lambs fed TPY_1 diet followed by MPY_1 diet when compared to control. This reduction in cost might be due to increased feed conversion efficiency and higher BW gains achieved by lambs apart from yeasts. The results of present study were in agreement with the findings of[15,33] in lambs fed diets with yeast.

Yield of carcasses and non-carcass components

The findings of the present study indicate that besides sustaining sheep in the dry seasons with the feeding of straw based complete diet supplemented with yeasts has a potential to produce carcasses of fair conformation and fatness. Dressing percentage was not affected by the test diets, though there was a higher ($P<0.01$) carcass weight in lambs fed yeast supplemented diets compared to control. The results were consistent with the findings of[13] in lambs fed yeast supplemented diets. The proportions of different carcass cuts were comparable and were not affected (except proportions of leg) among the dietary treatments. Significantly ($P<0.05$) higher proportions of leg was recorded in all the lambs followed by shoulder and neck, fore shank and brisket, rack and loin indicating, this part of the carcass was well developed. Similar results were reported[17] in lambs fed yeast supplemented diets.

The percentage of lean and bone was comparable among the treatments. The observed variation in fat content in the carcasses may have resulted from differences in dietary energy intake which were 7.90, 8.51 and 9.38 MJ, ME/day for the animals in CON, MPY_1 and TPY_1 diets, respectively. Feeding regimen affects carcass composition of farm animals particularly the fat content when there is variation in energy concentration and intake of diets[26]. The proportion of lean, bone and fat were optimum and comparable to the proportions reported[13,17] in lambs fed yeast supplemented diets. Thermotolerant yeast supplemented diet improved very slight proportions of lean meat followed by other two rations. This result was in agreement with the findings of[22] in steers fed diets supplemented with yeast cultures. The bone to meat ratio recorded was non-significantly higher on diet with thermotolerant yeast indicating, favourable condition provided by yeast for good quality meat. Similar results were reported by[21] in ram lambs fed yeast supplemented diet. Bone to meat ratio recorded in current study was higher than those recorded[25] indicating, all the test rations were efficient in formation of high quality meat. Higher ($P<0.01$) per cent weights of edible and lower ($P<0.01$) per cent weights of non edible components in carcasses of lambs supplemented with yeasts were recorded compared to lambs fed CON diet. These results were in agreement with the findings of[13,21] in lambs fed yeast supplemented diets.

Table 1. Ingredients and chemical composition of experimental diets

Item	Test diets^{a}		
	CON	MPY_1	TPY_1
Ingredients (g/kg DM)			
Sorghum straw	500.00	500.00	500.00
Maize	140.00	140.00	140.00
Groundnut cake	135.00	135.00	135.00
Sunflower cake	140.00	140.00	140.00
Molasses	70.00	69.00	69.00
Mineral and vitamins^{b}	10.00	10.00	10.00
Common salt	5.00	5.00	5.00
Mesophilic yeast culture	—	1.00	—
Thermotolerant yeast culture	—	—	1.00
Feed cost/tonnes (£)	72.77	73.38	73.38
Nutrient (g/kg DM)			
Dry matter	899.00	891.60	892.00
Organic matter	908.70	911.00	915.50
Crude protein	118.00	118.20	119.00
Neutral detergent fibre	547.00	557.00	565.50
Acid detergent fibre	346.30	357.70	366.30
Nutritive value of diets^{c}			
ME (MJ/kg DM)	8.69	9.06	9.43

a Test diets were (1) No yeast (CON; *n*=6) (2) with 1g/kg mesophilic yeast (MPY_1; *n*=6) (3) with 1g/kg thermotolerant yeast (TPY_1; *n*=6).

b Vitamin supplement was added @ 10 g/100 kg diet and composition per 1 kg contained (vitamin A, 4,50,000 IU; vitamin D3, 1,100,0000 IU; vitamin E, 3.18g; Mn,10.9 g; I,1.09 g; Zn, 22.73 g; Fe, 22.73 g; Cu, 2.73 g; Co, 0.635; Mg, 100 g; Se, 0.1g).

c Nutritive value of diets; calculated using NRC (1985).

Table 2. Least square means for *in vitro* gas production of experimental diets

IVGP profiles	Test diets with level of thermotolerant yeast (g/kg)^{1}				
	CON	TPY_1	TPY_2	TPY_3	SEM
IVGP (ml/200 mg DM)	45.50^{a}	49.33^{b}	50.00^{bc}	50.50^{bc}	0.61
IVOMD (mg)	100.10^{a}	108.53^{b}	110.00^{bc}	111.10^{bc}	1.34
ME (MJ/kg DM)	8.39^{a}	8.91^{b}	9.00^{bc}	9.07^{bc}	0.08
TDOM (mg)142.80^{a}	161.22^{b}	162.83^{bc}	163.38^{c}	2.59	
PF (mg/ml)*3.14^{a}	3.27^{b}	3.26^{b}	3.24^{ab}	0.02	
MBP (mg)42.70^{a}	52.68^{b}	52.83^{b}	52.28^{b}	1.35	
EMBP (g/kg)*	299.00^{a}	326.79^{b}	324.42^{b}	319.97^{ab}	3.95

a, b, c :
means with different superscripts row wise differ significantly (P<0.01); *(P<0.05).

1 Test diets were (1) No yeast (CON) (2) with thermotolerant yeast 1 g/kg (TPY_1) (3) with 2g/kg thermotolerant yeast (TPY_2) (4) with 3 g/kg thermotolerant yeast (TPY_3).

Table 3. Least square means for intake and growth performance of Nellore ram lambs fed experimental diets

Variable	Test diets[1]			
	CON	**MPY_1**	**TPY_1**	**SEM**
Nutrients intake				
Dry matter intake (g/day)	908.27^{a}	938.78^{a}	994.06^{b}	12.29
DM intake (% BW)	3.95^{a}	4.02^{a}	4.04^{b}	0.02
DM intake g/kg$W^{0.75}$/day	86.47^{a}	88.30^{a}	90.01^{b}	0.53
Organic matter (g/day)	847.28	857.71	891.36	9.90
Crude protein (g/day)	119.96	122.19	122.51	0.92
Neutral detergent fibre (g/day)	466.38^{a}	472.15^{a}	523.55^{b}	9.38
Acid detergent fibre (g/day)	300.86^{a}	311.84^{a}	351.01^{b}	6.70
Energy intake (ME, MJ/day)[2]	7.90^{a}	8.51^{b}	9.38^{c}	0.18
Growth performance				
Initial body weight (kg)	12.27	12.33	12.40	0.08
Final body weight (kg)	25.33^{a}	27.13^{b}	29.70^{c}	0.78
Total gain (kg)	13.07^{a}	14.80^{b}	17.30^{c}	0.75
ADG (g)[3]	72.59^{a}	82.22^{b}	96.11^{c}	4.18
FCR[4*] 12.51^{c}	11.42^{b}	10.34^{a}	2.56	
Cost/kg gain (Rs.)[*]	75.20^{c}	69.60^{b}	66.40^{a}	1.08

a, b, c :
Means with different superscripts row wise differ significantly ($P<0.01$); [*]($P<0.05$).

1 Test diets were (1) No yeast (CON; *n*=6) (2) with 1g/kg mesophilic yeast (MPY_1; *n*=6) (3) with 1g/kg thermotolerant yeast (TPY_1; *n*=6).

2 ME: metabolizable energy; calculated using NRC (1985).

3 ADG = average daily gain ((final weight – initial weight)/180 days).

4 FCR (kg DM intake/kg gain) = feed conversion ratio

Table 4. Least square means of carcass and non-carcass components of Nellore ram lambs fed experimental diets

Variable	Test diets[1]			
	CON	**MPY_1**	**TPY_1**	**SEM**
Fasting body weight (kg)	25.50^{a}	27.60^{b}	29.80^{c}	0.53
Carcass weight (kg)	12.85^{a}	14.05^{b}	15.19^{c}	0.31
Dressing percentage	50.39	50.90	50.96	0.33
Per cent proportions of carcass cuts				
Leg[*]	33.14^{ab}	31.63^{a}	34.36^{b}	0.53
Loin	12.46	12.91	10.83	0.62
Rack	14.10	11.75	12.32	0.66
Shoulder and neck	23.09	25.60	26.14	0.67
Fore shank and brisket	17.22	18.11	16.36	0.71
Non-carcass components				
Edible components weight (kg)	0.85^{a}	1.09^{b}	1.27^{c}	0.05
Edible components (%)	3.33^{a}	3.95^{b}	4.27^{b}	0.13
Non-edible components weight	2.76^{b}	2.59^{a}	2.53^{a}	0.06
Non-edible components (%)	10.82^{b}	9.38^{a}	8.47^{a}	0.36
Edible to non-edible components ratio	1:0.31	1:0.42	1:0.50	0.05
Proportion of lean (%)	62.09	62.19	63.48	0.40
Proportion of bone (%)	20.82	21.34	20.99	0.12
Proportion of fat (%)	17.09	16.47	15.54	0.37
Bone to meat ratio	1:2.98	1:2.93	1:3.02	0.05

a, b, c : Means with different superscripts row wise differ significantly ($P<0.01$); [*]($P<0.05$).

1 Test diets were (1) No yeast (CON; *n*=6) (2) with 1g/kg mesophilic yeast (MPY_1; *n*=6) (3) with 1g/kg thermotolerant yeast (TPY_1; *n*=6).

CONCLUSION

Treatment of sorghum straw based complete diet supplemented with thermotolerant yeast increased dry matter intake, resulted in improved live weight gain and carcass conformation, even when compared to mesophilic yeast. Thermotolerant yeast supplementation, however had limited effects on meat traits. Increased dressing percentage with variation in lean and fat proportions in thermotolerant yeast supplemented diet appears to be beneficial to the farmers. Investigation on the economics and practical aspects of this technology at farmers level is recommended.

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