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Effect of Different Feeding Methods on Milk Production and Composition of Lactating Punganur Cows

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ABSTRACT

The present experiment was conducted during January–August, 2021 at Livestock Research Station, Palamaner, Chittoor, Andhra Pradesh, India to study the effect of different feeding methods on production performance in lactating Punganur cows. A lactation study of 90 days duration was conducted on 16 lactating Punganur cows which were distributed (CRD) into four treatment groups comprising of 4 animals each. Animals of Control group were maintained as per the feeding practice followed by the farmers rearing Punganur cows in Chittoor district (Hedge lucerne, Paddy straw and Concentrate mixture), T_2 group fed with Super Napier grass Paddy straw and Concentrate mixture, T_3 group fed with Paddy straw, concentrate mixture and UMMB and T_4 group fed with TMR. The average FCM yield (kg d^{-1}) was highest (p<0.05) in T_4 followed by T_3 or T_2 and lowest in T_1. The Protein and lactose content (%) of milk was highest (p<0.05) in T_4 and lowest in T_3, while Fat and SNF (%) remained unaltered. The efficiency of milk production (kg/kg FCM) of DMI and TDNI lowest (p<0.05) in T_4, While CPI and DCPI lower (p<0.05) in T_4 or T_3 as compared to T_2 or T_1. The cost economics of milk production indicated that the feed cost (₹) per kg FCM yield was lowest (p<0.05) in T_3. The study concluded that the feed conversion efficiency in terms of DM, CP and Gross energy was highest for TMR group, while cost economics of milk production was better in Paddy straw, concentrate mixture, UMMB and TMR group.

KEYWORDS: Cost economics, feed efficiency, lactation trial, punganur cows

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1. INTRODUCTION

India is an agriculture-based country and livestock are the most important and essential sub division of our economy contributing 4.11% Gross Domestic Product and 25.6% of total Agriculture Gross Domestic Product in which major part comes from milk and milk products (Anonymous, 2020). Livestock playing pivotal role in accelerating the rural economy and ultimate sustainable livelihood for 70% population in rural areas. India possesses 192.52 million cattle which constitute nearly 12.7% of the world's total cattle population. The Indigenous/Non-descript cattle population in country is 142.11 million and in Andhra Pradesh is 1.44 million, with increase of crossbred population by 29.3% and decline of 6% indigenous cattle population. The milk production from crossbred cattle has increased by 10.95% and there was 3% decline in the milk production in Indigenous/Non-descript cattle (Anonymous, 2019). India has been blessed with a large repository of indigenous bovine population with rich biodiversity. The Indian subcontinent is a treasure house of the Bos indicus cattle. There are 43 Indigenous breeds in India (Anonymous, 2018).

Indigenous cattle in India are robust, resilient and are particularly suitable to the climate and environment of their respective breeding tracts. They are endowed with qualities of heat tolerance (Kapila et al., 2013 and Kumar et al., 2017), resistance to diseases and ability to thrive under extreme climatic stress and less optimal nutrition (Srivastava et al., 2019).

In recent years, several indigenous breeds suffered decline mainly due to their crossbreeding with exotic breeds and the large-scale mechanization of agricultural operation. Hence it is not only essential to promote conservation and development of indigenous breeds but also to enhance productivity through professional management and appropriate nutrition.

Dwarf cattle breeds have special niche in the context of sustainability because of their limited feed requirements (Ekambaram et al., 2014). Their smaller body size, good grazing habits, adaptability to local conditions, resilience to diseases, less feed requirement are beneficial marginal or landless dairy farmers (Srinivas and Ramesha, 2014). Farmers believe that the milk of these indigenous cows has medicinal properties, whereas the dung and urine are extensively used for organic farming and for preparation of various products with medicinal values and it is considered as sacred cow (Srinivas and Ramesha, 2017). Less attention was focused on improvement of dwarf cattle breeds in the past owing to their low milk yield without giving much consideration to other advantages (Manjunatha et al., 2020).

'Punganur' is a unique dwarf cattle breed, which originated from Chittoor district of Andhra Pradesh in Southern India is one among the world's smallest humped (*Bos indicus*) cattle breed weighing about 150–200 kg. They are fair milkers producing 2–3 kg milk day^{-1} and were known as the "Poor man's cow" (Ekambaram et al., 2014). Punganur cows reared solely on grazing by the majority of farmers in the rural areas (Ekambaram et al., 2014). So, the production potential has not yet been fully explored. Although this method of rearing renders many benefits, but it might not be enough to meet the nutrient requirements of the cows, and thus not fully utilizing the genetic potential of the breed. In order to maximize the milk production, it is necessary to meet the nutritional requirements of the animal by appropriate feeding method suitable for the agroclimatic conditions. Scientific feeding of livestock is one of the measures to solve the problem of shortage of feed and fodders that is faced at present by the farmers. Hence this experiment was planned to study a sustainable feeding method with optimal nutritional requirements for improved milk production in lactating Punganur cows.

2. MATERIALS AND METHODS

2.1. Location and period of study

The study was conducted on lactating Punganur cows maintained in Livestock Research Station, Palamaner, Chittoor, Andhra Pradesh, India, which is located at 13.1951440 latitude and 78.7010990 longitude. The trial was conducted in between January and August 2021, when the minimum and maximum temperatures were 21°C and 42°C respectively, with relative humidity (RH) ranging from 60-78 percentage (%) and THI between 82 and 86.

2.2. Experimental animals and design

16 lactating Punganur cows (168.66±5.94 kg) which are in 2nd and 3rd parity during 3–4th week of lactation were allocated randomly (CRD) into four treatment groups comprising of 4 animals each.

2.3. Experimental feeds and rations

Animals of control group (T_1) fed with Hedge lucerne (10 kg animal^{-1} day^{-1}), Paddy straw (2-3 kg animal^{-1} day^{-1}) and concentrate mixture @ 0.5 kg animal^{-1} day^{-1}, which is the common feeding practice followed by the farmers in the area under study. The hedge lucerne fed to the animals was harvested at 50 days. Animals of T_2 group fed with Super Napier grass *Ad libitum,* Paddy straw (1 kg animal^{-1} day^{-1}) and concentrate mixture @ 1 kg 2 l^{-1} milk production. The Super Napier grass was harvested at 60 days of growth, chaffed with chaff cutter and fed to the animals. Animals of T_3 group fed with Paddy straw *Ad libitum,* concentrate mixture @ 1 kg 2 l^{-1} milk production and urea molasses mineral block (UMMB) free access. The concentrate mixture used in this experiment contained 20% CP was prepared by using following ingredients such as maize 40%, de-oiled rice bran 23%, soybean meal 34%, mineral mixture 2%, and salt 1%. The urea molasses mineral block (UMMB) was prepared by using molasses 30%, urea 10%, maize 5%, de-oiled rice bran 20%, maida10%, sunflower cake10%, mineral mixture 15% were used as supplement in the T_3 group. Animals of T_4 group fed with Total mixed ration (TMR) @ 2.5% kg B. Wt. The total mixed ration was prepared by using super napier (*Cenchrus purpureus*) grass as sole source of roughage by harvesting at 60 days. The grass was chaffed, dried and ground in a chaffer cum grinder and then used for the preparation of complete rations by mixing in a horizontal mixer. The concentrate ingredients used are maize 20%, de-oiled rice bran 12%, soybean meal 5%, mineral mixture 2%, and salt 1%, So as to contain 12% crude protein.

2.4. Housing and feeding management

The experimental cows were housed in a well-ventilated milking shed maintained hygienically and stall fed throughout the experiment. Fresh chopped Hedge lucerne, Super Napier grass and Paddy straw were fed at 10 AM and 5 PM every day to the experimental cows individually according to the treatments in T_1, T_2 and T_3. The T_3 group animals were provided additionally with urea molasses mineral blocks (UMMB) to have free access. The TMR was provided to T_4 group animals twice daily in the morning and evening. While the daily concentrate mixture allowance was fed twice before milking (3 AM and 3 PM) for T_1, T_2 and T_3 animals. The animals were offered fresh, clean drinking water free of choice.

2.5. Body weights

The body weights of lactating animals were recorded at the beginning of the experiment and thereafter at fortnightly intervals during the experimental period to observe the changes. Body weight was recorded on two consecutive days and average of the two observations was considered as the actual weight. The body weight was recorded in the morning at 8.00 AM before offering water and feed to the animals.

2.6. Daily feed intake

Daily intake of concentrate, green and dry fodder was recorded for individual animals. Measured quantity of feeds and fodders were offered to experimental animals as per treatment and leftover feed was measured next day morning to know the actual amount of feed consumed by animals.

2.7. Daily milk yield and milk composition

The animals were completely hand milked twice daily at 4.00 A.M and 4.00 P.M throughout the experimental period and daily milk yield of individual cows was measured using digital weighing balance. Representative samples of milk from morning and evening were pooled proportionately and collected in to sterile milk sample bottles (at weekly intervals) and were analysed for fat, SNF, protein, lactose by using Milkoscan Minor type 78110. The ash content in the milk analysed as per (Anonymous, 2019).

2.8. Production performance

2.8.1. Fat corrected milk

From the milk and fat yield of animals, the 4% fat corrected milk (FCM) was calculated by the following equation given by (Rice et al., 1970)

4% FCM=0.4 (MY)+15 (FY)

where, MY, milk yield and FY, fat yield.

2.8.2. Milk energy

Milk energy was calculated (Tyrell and Reid, 1965) as follows

Milk energy (MJ/kg of milk)=(41.63 (% Fat)+24.13 (% Protein)+21.6 (% Lactose)-11.72)×2.2/239 (Anonymous, 2001)

2.8.3. Solid corrected milk (SCM)

SCM = 12.3(F)+6.56 (SNF) + 0.0752(M)

where, F=kg of milk fat, SNF=kg of solid not fat, M=kg of milk yield

2.8.4. Energy corrected milk (ECM)

ECM=7.2 X P+12.95 X F+0.327 X M

where, P = Milk protein (kg), F= Fat yield (kg), M= Milk yield (kg)

2.8.5. Gross energy efficiency

Gross energy efficiency of milk production was calculated according to the procedure of Brody, (1945).

GEE ={(FCM×750)/(TDN consumed (kg)×4400)}×100

2.8.6. Gross protein efficiency

Gross protein efficiency for milk production was calculated by using formula of Jumah et al. (1965).

GPP ={((Milk yield × Protein %) /100)/(DCP intake)}×100

2.8.7. Feed conversion efficiency (FCE)

FCE=kg FCM/kg DMI

Where, FCM=Fat corrected milk, DMI=Dry matter intake

2.9. Statistical analysis

The results of lactation trail obtained were subjected to analysis through software (version 17.0: SPSS, 2005) by applying one way analysis of variance through generalized linear model and the treatment means were ranked using Duncan's multiple range test (Duncan, 1955) with a test of significance at p<0.05 All the statistical procedures were done as per Snedecor and Cochran (1980).

3. RESULTS AND DISCUSSION

3.1. Body weights

During lactation study, the body weights of animals indicated non-significant (p>0.05) gain in body mass (137.03-337.03 g/d) which indicated that the experimental rations could able to meet the nutritional requirements of the lactating cows and the animals are in positive energy balance (Table 1). The results are in agreement with the reported results of Manjunatha et al. (2020) who indicated non-significant (85-136 g d^{-1}) body weight gain in Malnad Gidda lactating cows, fed 10 and 20% more than the nutrient requirements (Anonymous, 2013).

Table 1: Body weight gain (g d^{-1}) in lactating Punganur cows during lactation trial

Treatment	Initial weight (kg)^{NS}	Final weight (kg)^{NS}	Body weight gain (kg)^{NS}
T_1	160.33±7.53	180.33±11.92	222.25±0.050
T_2	166.33±20.01	178.66±21.26	137.03±0.032
T_3	167.66±15.45	188.33±19.42	229.63±0.045
T_4	172.25±3.51	202.33±2.18	337.03±0.014

NS: Values in the column do not differ significantly (p>0.05)

3.2. Milk yield

The average daily milk yield (kg d^{-1}) was significantly (p<0.05) higher in T_4 or T_3 as compared to T_2 or T_1 (Table 2). While average 4% Fat Corrected Milk (FCM) yield was found to be significantly (p<0.05) highest in T_4. The FCM yield (kg d^{-1}) in T_3 and T_4 was 61.7% and 71.3% more than T_1. Results of present study is corroborated with the results of Ekambaram et al. (2014) who fed the Punganur cows with 10 or 20% less requirements (Anonymous, 1985). Whereas Manjunatha et al. (2020) opinioned that providing the optimal nutrients to Malnad Gidda cows increased the milk production marginally (0.5 kg day^{-1}) as compared to unorganized system. The milk yield predominantly depends on breed, parity and feeding practices are in agreement with Parameshwara et al. (2020) and Chandra Mouli et al. (2022). The higher milk and FCM yield (kg d^{-1}) in Paddy straw, concentrates and UMMB (T_3) group in the present study are in accordance with the results reported by Mohini and Singh, (2010), Murthy et al. (2013) and Meel et al. (2015) in cross bred cows who opinioned that UMMB feeding increased voluntary straw intake which was associated with the higher cellulolytic activity and fibre utilization by the microbes in the presence of the optimum urea ammonia provided by UMMB. Increase in milk production indicated

Table 2: Average milk yield and milk composition of Punganur cows during lactation trial

Parameter	Treatments			
	T_1	T_2	T_3	T_4
Milk yield (kg d^{-1})				
Daily milk yield (kg $animal^{-1}$ day^{-1})*	1.54±0.11^{a}	1.69±0.06^{a}	2.35±0.30^{b}	2.48±0.20^{b}
FCM yield (kg $animal^{-1}$ day^{-1})*	1.67±0.13^{a}	1.97±0.26^{ab}	2.70±0.31^{bc}	2.86±0.22^{c}
Milk composition (%)				
Fat	4.51±0.10	5.05±0.72	4.79±0.30	4.99±0.14
SNF	9.40±0.01	9.36±0.18	9.39±0.06	9.63±0.05
Protein*	4.05±0.04^{bc}	3.95±0.01^{ab}	3.84±0.06^{a}	4.23±0.09^{c}
Lactose*	4.35±0.01^{a}	4.37±0.02^{ab}	4.31±0.08^{a}	4.42±0.02^{b}
Total solids	13.83±0.17	14.42±0.62	14.19±0.36	14.63±0.09
Ash	0.74±0.05	0.74±0.05	0.75±0.05	0.73±0.08
Milk components yield (g d^{-1})				
Fat*	70.17±6.01^{a}	86.41±15.80^{ab}	115.94±14.35^{b}	124.64±8.78^{b}
SNF*	145.63±10.30^{a}	158.60±4.09^{a}	226.33±25.47^{b}	243.53±22.38^{b}
Protein*	62.69±4.78^{a}	66.80±2.53^{a}	91.67±9.25^{b}	105.02±9.08^{b}
Lactose*	67.34±4.76^{a}	72.94±2.22^{a}	103.94±12.27^{b}	107.97±10.95^{b}
Total solids*	215.83±16.24^{a}	245.39±18.25^{a}	342.25±35.94^{b}	366.18±31.77^{b}
Ash*	11.51±0.90^{a}	12.53±0.37^{a}	17.79±2.57b	18.15±1.60^{b}

abc Values in a row bearing superscripts differ significantly *(p<0.05) that if basal diet is deficient in major nutrients, part of it can be fulfilled through UMMB supplementation (Perera et al., 2007). The higher milk and FCM yield (kg d^{-1}) in TMR (T_4) group might be due to higher propionate production as the combination of feed ingredients increases nutrient density and efficiency of ME utilization which might have resulted in higher milk production than those fed concentrates and roughages separately as in the conventional ration (Walli, 2015, Mohammad et al., 2017; Teshome et al., 2017, Patil et al., 2020).

3.3. *Milk composition*

The average milk fat (%) ranges 4.51–5.05% in T_1 to T_4, respectively and non-significant (Table 2). Though there were non-significant differences in fat (%) among the different treatments, when average fat yield (g d^{-1}) was considered highest (p<0.05) was observed in T_4 or T_3 followed by T_2 and lowest in T_1. This is due to the higher milk yield observed in other groups as compared to the control. Ekambaram et al. (2014) reported marginally higher fat (4.65–5.85%) of Punganur cows, whereas Manjunatha et al. (2020) reported lower fat (4.10-4.39%) in Malnad Gidda cows which are dwarf breeds.

Similar trend was also observed with milk SNF (9.36-9.63%) and yield (145.63-243.53 g d^{-1}) was higher (p<0.05) in T_4 or T_3 as compared to T_2 or T_1. The present findings are in agreement with Ekambaram et al. (2014), while Manjunatha et al. (2020) reported slightly lower SNF (8.91–8.96%) and yield (0.20–0.21 kg d^{-1}) in Malnad Gidda cows.

It was interesting to know that the average milk protein (%) indicated significant (p<0.05) improvement in T_4 as compared to other treatments, which was also reflected in milk protein yield (g d^{-1}) resulting in 6.5, 46 and 69.4% improvement in T_2, T_3 and T_4 groups as compared to control. Ekambaram et al. (2014) reported marginally higher protein content (4.31-4.41%) in Punganur cows, while Manjunatha et al. (2020) reported lower protein (3.27–3.29%) and protein yield (0.07-0.08 kg d^{-1}) in Malnad Gidda cows. Increase in protein content of milk might be due to significant increase in Gross protein efficiency (Kumar, 2012). Similar to the present study, Macleod et al. (1983) found that protein content of milk increased from 3.11–3.26% when reducing the ratios of forage: concentrates from 80:20 to 65:35. The ratio of Roughage to concentrate in the present study was 60:40, that would have resulted in the optimal protein utilization.

The average lactose (%) was found to be significantly (p<0.05) highest in T_4 followed by T_2 and lowest in T_1 or T_3. Whereas the average milk lactose yield (g d^{-1}) was significantly (p<0.05) higher in T_4 or T_3 as compared to T_2 or T_1. Manjunatha et al. (2020) reported higher lactose (%) content and lactose yield in Malnad Gidda cows.

The average total solids (%) ranged 13.83–14.63% in T_1 to T_4, respectively and non-significant. But the average milk total solids yield (g/d) were significantly (p<0.05) higher in T_4 or T_3 as compared to T_2 or T_1. The values observed in the present study for total solids (%) are within the reported range by Ekambaram et al. (2014) and Manjunatha et al. (2020) in Punganur and Malnad Gidda cows.

As the experiment progressed, milk yield increased therefore average yield of milk components (g d^{-1}) for Fat, SNF, Protein, lactose and total solids was significantly (p<0.05) improved in T_4 or T_3 as compared to T_2 or T_1 experimental groups. It is evident that there are lots of genetic and non-genetic factors responsible for variability in milk yield and composition like breed, heredity, parity, diet, time and frequency of milking, season etc. (Sarker et al., 2019, Pandiyan et al., 2022).

3.4. *Total milk yield (kg) and milk components yield (g) in lactating punganur cows*

The total milk yield (kg) recorded during 90 days of experimental period was significantly (p<0.05) higher in T_4 or T_3 as compared to T_2 or T_1 (Table 3). Total FCM yield (kg) was significantly (p<0.05) highest in T_4 followed by T_3,

Table 3: Total milk yield (kg) and yield of milk components (g) in lactating Punganur cows during lactation trial*

Parameter	Treatments			
	T_1	T_2	T_3	T_4
Total milk Production (kg)*	139.27±10.07^a	152.49±5.94^a	212.27±27.24^b	221.70±19.33^b
Total FCM yield (kg)*	236.55±34.10^a	305.73±51.76^{ab}	596.86±1.35^{bc}	647.79±1.10^c
Total fat yield (g) *	94.59±8.29^a	117.16±21.02^a	153.60±20.87^b	166.27±11.67^b
Total SNF yield (g)*	196.87±13.89^a	214.37±5.48^a	299.68±37.21^b	321.52±29.18^b
Total protein yield (g) *	84.72±6.47^a	90.26±3.42^a	121.31±13.75^b	140.57±10.57^b
Total lactose yield (g) *	90.97±6.43^a	100.05±3.74^a	137.60±17.78^b	147.12±12.27^b
Total solids yield (g)*	289.91±23.59^a	331.53±26.48^{ab}	453.27±57.02^{bc}	487.79±40.26^c

abc Values in a row bearing superscripts differ significantly *(p<0.05); * Values are average of 4 animals for 90 days trial period

T_2 and lowest in T_1. The total fat, SNF, protein and lactose yield (g) were higher (p<0.05) in T_4 or T_3 as compared to T_2 or T_1, while total solids yield (g) was highest (p<0.05) in T_4 followed by T_3, T_2 and lowest in T_1. The results indicated that there was an increase of 9.46, 52.40 and 59.15% in milk yield and 29.2, 152.28 and 173.8% of FCM yield in T_2, T_3 and T_4 as compared to T_1. Milk composition did not influence much, but the yield of total milk and milk components were influenced by the feeding regimes.

3.5. Feed conversion efficiency

The DMI kg/kg milk yield and g/kg FCM was significantly (p<0.05) highest in T_2 followed by T_1 or T_3 and lowest in T_4. The results indicated that cows in total mixed ration T_4 group required lowest amount of DMI for producing one kilogram of milk. The values in the present study are comparable with the values reported by Gami et al. (2019) in Kankrej cows. Present findings differ moderately with the reported values for DMI of 1.15-1.20 kg/kg milk yield and DMI 1.02-1.14 kg/kg FCM by Miachieo et al. (2006) in Sahiwal cows. The CPI g/kg milk yield and g/kg FCM was significantly (p<0.05) lower in T_4 or T_3 requires less amount of CPI (g/d) than those in T_2 or T_1 for producing one kilogram of milk. The cows in T_4 group required lowest amount of TDN for producing one kilogram of milk (Table 4).

The feed conversion efficiency in dairy cattle is known to be affected by various factors, including host genetics, environmental conditions such as ambient temperature, the varying metabolic contributions and days in milk, because cows in early lactation will be losing body weight and using that energy for milk, demands of pregnancy, tissue mobilization, and immune response are other factors influencing the feed efficiency. (Jewell et al., 2015).

3.6. Nutrient utilization efficiency

The milk energy (MJ/kg milk) calculated according to NRC, (2001) was in the range 3.38- 3.62 MJ/kg milk in T_1 to T_4 and non-significant. Present findings are slightly higher than the reported values (3.17-3.29 MJ/kg milk) by Manjunatha et al. (2020) in Malnad Gidda cows. The milk energy content of Punganur cows was lower than the values obtained for pure and cross bred cows which were reported to be 5.2 MJ/kg milk (Mcdonald, 1999). The Gross energy efficiency (%) was significantly (p<0.05) higher in T_4 which revealed that better efficiency of energy utilization in TMR feeding. The Gross protein efficiency (%) was higher (p<0.05) in T_4 or T_3 revealed that cows in

Table 4: Effect of different feeding methods on Feed conversion and Nutrient utilization efficiency in lactating Punganur cows

Parameters	Treatments			
	T_1	T_2	T_3	T_4
DMI (kg d^{-1})*	4.18±0.08^{a}	5.61±0.06^{c}	5.88±0.11^{c}	4.75±0.06^{b}
Milk yield (kg d^{-1})*	1.54±0.11^{a}	1.69±0.06^{a}	2.35±0.30^{b}	2.48±0.20^{b}
FCM (kg d^{-1})*	1.67±0.13^{a}	1.97±0.26^{ab}	2.70±0.31^{bc}	2.86±0.22^{c}
Feed conversion efficiency				
DMI (kg kg^{-1} milk yield)*	2.74±0.23^{bc}	3.32±0.14^{c}	2.57±0.29^{ab}	1.94±0.17^{a}
DMI (kg kg^{-1} FCM yield)*	2.54±0.24^{ab}	2.94±0.38^{b}	2.23±0.24^{ab}	1.68±0.14^{a}
CP intake (g kg^{-1} milk yield)*	296.46±23.40^{b}	289.33±12.02^{b}	211.20±16.76^{a}	218.44±18.24^{a}
CP intake (g kg^{-1} FCM yield)*	274.79±21.84^{b}	256.15±33.21^{ab}	183.49±14.22^{a}	189.80±15.45^{a}
DCP intake (kg kg^{-1} milk yield)*	0.179±0.01^{b}	0.177±0.01^{b}	0.124±0.01^{a}	0.129±0.01^{a}
DCP intake (kg kg^{-1} FCM yield)*	0.166±0.01^{b}	0.157±0.01^{ab}	0.108±0.01^{a}	0.112±0.01^{a}
TDN intake (kg kg^{-1} milk yield)*	1.72±0.03^{bc}	1.99±0.06^{c}	1.58±0.21^{ab}	1.25±0.07^{a}
TDN intake (kg kg^{-1} FCM yield)*	1.59±0.04^{b}	1.76±0.19^{b}	1.37±0.17^{ab}	1.08±0.05^{a}
Nutrient utilization efficiency				
Milk energy (MJ kg^{-1})	3.38±0.04	3.56±0.27	3.43±0.12	3.62±0.05
Gross energy efficiency (%)*	11.14±0.89^{a}	13.16±1.75^{ab}	18.01±2.12^{bc}	19.07±1.49^{c}
Gross protein efficiency (%)*	26.91±2.08^{a}	28.71±1.14^{a}	38.63±4.42^{b}	45.09±3.27^{b}
Solid corrected milk (kg d^{-1})*	1.92±0.15^{a}	2.22±0.22^{ab}	3.01±0.39^{bc}	3.27±0.23^{c}
Energy corrected milk (kg d^{-1})*	1.86±0.15^{a}	2.15±0.24^{ab}	2.87±0.37^{bc}	3.16±0.21^{c}

abc: Values in a row bearing superscripts differ significantly *(p<0.05)

T_4 and T_3 utilized protein more efficiently than the cows in T_2 and T_1. The solid and energy corrected milk (kg/d) was significantly (p<0.05) highest in T_4 as compared to other treatments. The present findings are imitating with the study of O' Neil et al. (2011) who reported that cows offered TMR has higher solid corrected milk as compared to those fed with conventional feeding (Rye grass).

3.7. Cost economics of milk production

The total feed cost (₹) offered during 90 days lactation trial was significantly (p<0.05) highest in T_4 as compared to T_2 or T_1 or T_3 (Table 5). The feed cost (₹) per kg milk production and per kg FCM was found to be significantly (p<0.05) lower in T_3. The present findings are in agreement with (Yadav et al., 2012 and Suresh and Rao, 2013) who opinioned that the feed cost (₹) per kg FCM was economical in paddy straw, concentrates and UMMB group in cross bred cows. The value of milk sold (@ 100 ₹ kg^{-1}) found to be significantly (p<0.05) higher in T_4 or T_3 as compared to T_2 or T_1, whereas the value of milk sold (@100 ₹ kg^{-1}) FCM was found to be significantly (p<0.05) highest in T_4 followed by T_3, T_2 and lowest in T_1. The net benefit (₹) over feed cost for milk yield was significantly (p<0.05) higher in T_4 followed by T_4 and T_2 or T_1. While the net benefit (₹) over feed cost for FCM yield was significantly (p<0.05) higher in T_4 or T_3 as compared to T_2 or T_1. Similarly, Gaffar et al. (2011) reported net profit earned in a day/cow was highest in TMR group when compared with conventional ration. The income per day per animal for milk yield (₹) was significantly (p<0.05) highest in T_3 followed by T_4 and T_2 or T_1, whereas the income per day per animal for FCM yield was significantly (p<0.05) higher in T_4 or T_3 as compared to T_2 and T_1. This study indicated that net benefit over feed cost and income per day was higher in T_4 and T_3 group (Table 5).

Table 5: Cost economics of milk production in lactating Punganur cows

Parameter	Treatments			
	T_1	T_2	T_3	T_4
Total cost of feeding (₹)*	6,255±4.95^a	7,050±2.61^a	6,198±3.60^a	10,080±1.80^b
Total milk production (kg)*	139.27±10.07^a	152.49±5.94^a	212.27±27.24^b	221.70±19.33^b
Total FCM yield (kg)*	236.55±34.10^a	305.73±51.76^{ab}	596.86±1.35^{bc}	647.79±1.10^c
Feed cost kg^{-1} of milk*	45.26±4.00^b	46.24±0.08^b	29.72±2.07^a	46.23±4.51^b
Feed cost kg^{-1} of FCM*	27.49±3.93^c	24.11±3.12^{bc}	11.32±2.14^a	16.46±2.70^{ab}
Value of milk sold @ 100 ₹ kg^{-1} milk yield*	13,927±1.07^a	15,249±5.94^a	21,227±2.72^b	22,170±1.93^b
Value of milk sold @ 100 ₹ kg^{-1} FCM yield*	23,655±3.40^a	30,573±5.17^{ab}	59,686±1.35^{bc}	64.779±1.10^c
Net benefit over feed cost for milk yield (₹)*	7,671±1.02^a	8,198±1.28^a	15,028±2.38^b	12,090±2.06^{ab}
Net benefit over feed cost for FCM yield (₹)*	17,400±3.31^a	23,523±4.92^a	53,487±1.31^b	54,699±1.11^b
Income day^{-1} animal^{-1} from milk yield*	85.24±11.34^a	91.09±3.70^a	166.97±26.45^b	134.33±22.97^{ab}
Income day^{-1} animal^{-1} from FCM yield*	193.33±36.88^a	261.37±54.70^a	594.30±1.45^b	607.76±1.24^b

abc: Values in a row bearing superscripts differ significantly *(p<0.05)

In addition, there is a demand for urine for preparation of medicines and sanitary solutions and dung is extensively used for organic manure purpose, but both were excluded for economics calculation. If these two components are included with milk, the margin of the profit would have further been increased (Sabapara et al., 2015).

4. CONCLUSION

TMR and Paddy straw, concentrates and UMMB significantly improved both milk and FCM yield of the Punganur cows. The milk composition was not affected by the experimental rations. The feed conversion efficiency in terms of DM, CP and Gross energy was highest for TMR group. While cost economics of milk production was better in Paddy straw, concentrates and UMMB supplemented group and TMR group. There is a scope to improve the milk production by adopting scientific feeding methods.

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