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INFLUENCE OF TOTAL MIXED RATION ON PRODUCTIVITY AND COMPOSITION OF MILK OF LACTATING BUFFALOES UNDER THE DRY ZONE FARM CONDITIONS

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A 22-day lactation trial was conducted to determine the effect of total mixed ration on productivity and composition of milk of lactating buffaloes under the dry zone farm condition. Six Murrah × Nili-Ravi crossbred, early lactating buffaloes were blocked according to their parity and randomly allocated to two treatment groups. They were either offered a total mixed ration (TMR) or fed by conventional feeding system with only chopped guinea grass (control group). Milk yield, composition, feed intake were measured daily and milk urea nitrogen (MUN) and body weight were determined weekly. Economic efficiency was evaluated by cost-benefit analysis. Milk yield and average body weight were significantly higher ($p<0.05$) in animals fed with TMR (4.90 ± 0.13 L and 616.54 ± 2.55 kg, respectively) than those fed by the conventional system (2.67 ± 0.13 L and 604.99 ± 2.55 kg, respectively). Milk fat content was significantly higher ($p<0.05$) in TMR fed group while milk protein, density, solids-non-fat, and lactose contents were higher ($p<0.05$) in the control group. However, the MUN content was not significantly different ($p>0.05$) when fed with TMR or chopped guinea grass. Moreover, average feed intake was higher ($p<0.05$) in the control group (37.98 ± 0.44 kg) than the TMR fed group (28.56 ± 0.44 kg). A higher profit was reported with the TMR feeding (Rs. 29.42/animal/day) compared to the control group. The results reveal that TMR feeding do have a significant impact on milk yield and milk fat content of lactating buffaloes which improves the profit margin.

Keywords: Lactating buffaloes, Milk composition, Milk yield, Total mixed ration

In Sri Lanka, lactating buffaloes contribute approximately 17.31% of the national milk production, although the lactating cattle: buffalo ratio in the country is 4:1 (National Livestock Statistics, 2017). The milk production of both cattle and buffaloes are not enough to fulfill the demand of the country. When considering about the Buffaloes, they consume mature fibrous forages that cattle normally refuse. They have significantly greater voluntary feed intake, greater rumen capacity, greater rumen microbial content, lower frequency of rumen movement than cattle (Bhattacharyya and Mullick, 1965). These factors contribute to the superior dry matter, organic matter and cellulose digestibility and better ability to utilize poor quality roughages by Buffalo, compared to cattle (Wanapat, 1989).

Generally, buffalo milk contains more butterfat, total solids, calcium and phosphorous than cow milk (Cockrill, 1981). Buffalo milk has less cholesterol, but more tocopherol, a natural anti-oxidant. The peroxidase activity in buffalo milk is 2 - 4 times higher than cow milk and because of that buffalo milk can be preserved for a long time period (Borghese *et al.*, 2007). Buffalo milk is more suitable for the production of curd, butter, cheese, creams and milk powder, which have export value all over the world. Due to higher total solid content, the required number of units of buffalo milk for manufacturing a unit of dairy product is less than that of cow milk. Therefore, a farmer can earn a better price for buffalo milk than cow milk.

However, one of the major constraints faced by dairy farmers in dry zone is a severe drop in body condition of buffaloes during prolonged drought due to the scarcity of quality feeds (Ibrahim and Jayatileka, 2000). Therefore, animals decrease the production performance directly. Grazing is the major feeding method practiced by Sri Lankan farmers and there is no exception in the dry zone. Sometimes, grazing animals do not get all the nutritional requirements for the animal's maintenance, growth and production since their diet are not balanced and when animal graze over matured, fibrous, low-quality forage, they do not receive the required amount of nutrition for their activities.

Feeding TMR allows the mixing of all feed ingredients together based on a prescribed amount of each ingredient which allows the animal to receive a nutritionally balanced diet. When consuming TMR, animals do not sort the ingredients. When a TMR is mixed properly, a cow cannot consume significantly more or less of a forage or concentrate. Further, it allows more even rumen fermentation and a better use of nutrients than feeding separate ingredients. Blending all the feeds together in a TMR can mask the flavor of less palatable feeds. Moreover, ingredients such as urea, limestone, bicarbonate, fats, and by-pass protein sources like blood and fish meal can be added to TMR in reasonable amounts without significant reduction in feed consumption (Kumar, 2012). Increased milk yields were reported in TMR fed cows compared to the grazing cows (Kolver and Muller, 1998). Further, Nocek *et al.*, (1986) observed higher milk production efficiency in cows fed TMR than the cows supplemented with concentrates separately. There occurs high milk fat concentration with increase TMR feeding frequency (Sniffen and Robinson, 1987).

Feeding TMR to buffaloes may be the best method than grazing. If they are fed with TMR, they may show better productivity and which will economically beneficial to the farmer's income. Use of TMR rather than forage feeding may positively affect both animal and the farmer. Feeding TMR to buffaloes may fulfill daily nutrition requirement and reduce the reproductive disorders. Moreover, TMR feeding may improve the composition of buffalo milk. Therefore, this study was conducted mainly to evaluate the influence of TMR on productivity and composition of milk of lactating buffaloes under the dry zone farm condition.

MATERIALS AND METHODS

Location

Field works were conducted at Livestock farm, Faculty of Agriculture, Rajarata University of Sri Lanka. Laboratory analyses were conducted at the Animal and Food Sciences laboratory, Faculty of Agriculture and Veterinary Research Institute, Gannoruwa, Peradeniya, Sri Lanka.

Preparation of total mixed ration

Proximate composition of each ingredient was assessed by procedures described by Association of Analysis Chemists (AOAC, 1995) and gross energy was measured by bomb calorimeter. Quality checking of raw materials was done in the laboratory and ingredients were mixed according to recommendations of nutrient requirement of dairy cattle (NRC, 2001), nutritional requirements of buffaloes (Pathak and Verma, 1993).

Table 1: Ingredient composition in the total mixed ration (TMR)

Raw ingredient	**% in TMR**
Chopped hybrid Napier grass	30
Chopped guinea grass	19
Rice-bran	14
Gliricidia	08
Paddy straw	07
Coconut poonac	07
Corn	07
Soybean meal	04
Molasses	02
Vitamin-mineral premix	1.5
Salt	0.5

Experimental animals and design

A total of six, Murrah × Nili-Ravi crossbred lactating buffaloes (2nd & 3rd parities and average body weight 600 ± 20 kg) were selected from faculty farm. They were randomly assigned into two treatment groups; (T1: TMR feeding and T2:

Conventional feeding - fed only fresh chopped guinea grass) of three in a Randomized Complete Block Design (RCBD) based on their parity. One lactating buffalo was considered as an experimental unit.

Feeding and housing management

The animals were kept under shade and stalled fed. They were fed *ad-libitum* twice a day; at morning 8.00 a.m. and evening 5.00 p.m. Experimental period was of 22 days, including 7 days for adaptation and 15 days of the collection period. Water was sprayed to reduce the heat stress during the daytime. Buffaloes were machine milked twice a day early morning (3.30 a.m.) and evening at 3.30 p.m.

Analysis of feed samples

Representative feed samples (100 g) were randomly collected from prepared mixtures twice a week and pooled together. Pooled feed samples were dried and ground to pass through a 1 mm mesh and stored in sample bottles until analyze. Ground samples were analyzed for proximate composition and gross energy content as per the standard procedure described by Association of Official Analytical Chemists (AOAC, 1995).

Data collection and calculations

Daily feed intake was recorded by weighing the offered and refusal feed during the experimental period. Live body weights of animals were taken at the beginning of the trial and weekly intervals (before offering the feed) by a weigh-band. Feed conversion efficiency (FCE) was calculated using the following formula.

$$\text{Feed Conversion Efficiency (FCE)} = \frac{\text{Milk yield}}{\text{Dry matter intake}}$$

According to the feed intake, daily feed cost was calculated using the unit prices spent for purchasing of raw materials.

Milk yield was recorded daily at morning and evening and milk samples were also taken daily from each individual animal. Daily milk yield of each animal was measured using a digital weighing balance. The milk samples from morning and evening milking were pooled and milk composition of the individual animal was determined every day by lacto-scanner (Lactoscan SLP, Bulgaria).

Moreover, milk samples (50 mL) were randomly collected once a week from individual animals and samples were stored at freezer (-18ºC) until analysis of milk urea nitrogen (MUN). Modified colorimetric p-dimethylaminobenzaldehyde (DMAB) assay (Sigma ALDRICH, Switzerland) was used to determine MUN content in the milk. In the intensity of yellow colored complex of urea with DMAB reagent in an alcohol low acidic solution was measured using a UV-visible spectrophotometer (Orion aquamate 8000, United States) at 425 nm wavelength.

Data analysis

Daily milk yield, the composition of milk samples and MUN, feed intake and FCE were analyzed using the mixed procedure of Statistical Analysis System, Ver. 9.0 (SAS, 2002). Statistical significance was declared at p<0.05.

RESULTS AND DISCUSSION

Proximate composition of raw materials and total mixed ration

The chemical composition of raw materials and total mixed ration used in the experiment was presented in Table 2. Dry matter content of TMR was 34.43%. Total mixed ration contained 3.57%, 13.78%, 35.1% and 7.92% total ash, crude protein (CP), crude fiber (CF) and crude fat (EE), respectively. The gross energy content of TMR was 4224.61 Kcal/kg. The ration of buffaloes was formulated according to Pathak and Verma, (1993) and NRC (2001). It consisted of 40:60 of concentrate: roughage. All the nutrients of ration and raw materials were within values recommended by Pathak and Verma (1993) and NRC (2001).

Effect of treatment on milk yield and composition

There was a significant difference (p<0.05) in daily average milk yield of lactating buffaloes fed with TMR and conventional method (fed chopped guinea grass) during the study period (Table). Average milk yield was higher (p<0.05) in the lactating buffaloes fed with TMR compared to the Buffaloes in conventional feeding group. This was in agreement with the Fan *et al.* (2002), Bargo *et al.*, (2002), Girdhar and

Table 2: Proximate composition of raw materials and total mixed ration

Raw material / TMR	DM (%)	Ash (%)	CP (%)	CF (%)	EE (%)	GE (Kcal/kg)
Guinea grass	27.14 ± 0.30	11.57 ± 0.34	6.48 ± 0.98	36.51 ± 0.47	5.17 ± 0.74	4119.88
Hybrid -napier grass	26.98 ± 1.49	14.30 ± 0.26	11.36 ± 0.59	32.02 ± 0.53	4.52 ± 0.70	4036.39
Paddy straw	87.51 ± 0.51	13.25 ± 0.64	5.86 ± 0.41	35.03 ± 1.10	1.20 ± 0.52	3779.09
Coconut poonac	91.83 ± 0.57	3.90 ± 0.30	20.00 ± 1.26	25.30 ± 1.21	10.93 ± 1.19	4722.2
Rice bran	91.94 ± 0.76	4.53 ± 0.63	14.32 ± 0.40	14.25 ± 0.43	13.73 ± 0.91	5210.52
Corn	89.24 ± 0.43	2.19 ± 0.60	10.85 ± 0.62	3.20 ± 0.52	3.79 ± 0.24	4278.9
Gliricidia	29.15 ± 0.98	2.15 ± 0.70	16.72 ± 1.27	12.45 ± 0.42	2.87 ± 0.28	3278.35
Soybean meal	88.53 ± 1.07	6.90 ± 1.48	43.10 ± 0.37	5.23 ± 0.68	7.19 ± 0.10	4564.17
Molasses	84.47 ± 1.13	11.40*	3.06 ± 0.89	0.60*	0.20*	
TMR	34.43 ± 0.50	3.57 ± 0.27	13.78 ± 0.71	35.10 ± 0.49	7.92 ± 0.40	4224.61

Table 3: Effect of treatment on milk yield and composition of lactating buffaloes fed with total mixed ration and chopped Guinea grass

Parameter	Treatment		SE
	Total mixed ration	Conventional	
Milk yield (L)	4.90^{a}	2.67^{b}	0.13
Milk composition (%)			
Fat	8.78^{a}	7.95^{b}	0.20
Protein	2.72^{b}	2.84^{a}	0.02
Lactose	4.10^{b}	4.25^{a}	0.03
SNF	7.39^{b}	7.72^{a}	0.06
Density (kg/m^3)	21.76^{b}	23.75^{a}	0.29
pH	7.01^{a}	6.92^{b}	0.02
MUN (mg/dL)	9.80	8.82	0.63

$^{a,\,b}$ means within the same row with different superscripts are significantly different ($p<0.05$).

Significantly higher ($p<0.05$) milk fat content was observed in lactating buffaloes fed with TMR compared to buffaloes fed with the conventional method (Table 3). The results obtained in this study for milk fat agreed with the positive effects of TMR feeding on fat percentage in dairy cow and buffaloes. DeVries and Gill, (2012) and White *et al.*, (2001) reported that cows fed on TMR had higher ($p<0.05$) total milk fat percentage than those grazed on pasture. Further, Bargo *et al.*, (2002) reported, TMR feeding produced 38% more fat than cows on the pasture feeding treatment.

Balaraman, (2005), Schroeder *et al.*, (2005) and DeVries and Gill, (2012) who reported increased milk yield on TMR feeding as compared to separate feeding of concentrate and roughage.

Milk fat percentage is related positively to rumen molar percentages of acetic and butyric acids and negatively to that of propionic acid. Davis, (1978) reported that rumen molar percentage of propionate must be above 25 before a highly significant negative relationship between milk fat percentage and propionate to exist. Further, a positive relationship exists between the molar ratio of acetate to propionate and milk fat percentage. A linear increase in milk fat percentage occurs as the ratio of acetate to propionate increases up to 2.2 (Davis, 1978). Above a ratio of 2.2, there is little change in milk fat percentage. Thus, diets that increase propionate production have the greatest effect on milk fat percentage. Therefore, increase milk fat content observed with TMR feeding in our study may be due to the below 2.2 of acetate to propionate.

Generally, the maximum feed intake of dairy cows observed when neutral detergent fiber (NDF) content in the ration is 26 – 28% (Ahmed *et al.*, 2014). When increasing NDF percentage than optimum level, feed intake can be decreased. However, there was a very little difference in fiber content between chopped grass and TMR. Therefore, observed higher fat content in TMR fed group could be due to the maximum intake with proper ratios of volatile fatty acids.

Table 4: Feed intake, weight gain and feed conversion efficiency in lactating buffaloes fed with total mixed ration and chopped Guinea grass

Parameter	Treatment		SE
	Total mixed ration	Conventional	
Feed intake (kg/day)	28.56[a]	37.98[b]	0.44
Weight (kg)	616.54[a]	604.99[b]	2.55
Weight gain (kg/week)	3.59[a]	1.95[b]	0.15
FCE (%)	43.76[a]	23.57[b]	1.33

[a, b] means within the same row with different superscripts are significantly different ($p < 0.05$).

The average protein, SNF and lactose contents of milk were significantly greater ($p<0.05$) in conventional feeding group competed to TMR fed buffaloes. This was in agreement with the results of Girdhar and Balaraman, (2005) and Gaafar *et al*. (2010) who reported higher SNF and total solid contents on conventional feeding as compared TMR feeding. There was no significant difference ($p>0.05$) in average MUN content between buffaloes fed TMR and chopped Guinea grass. Under typical production conditions, most dairy herds should have MUN concentrations between 8 - 12 mg/dL. Herds with high MUN have been found to be at risk for overfeeding protein and herds with low MUN have been found to be at risk for underfeeding of protein (Kohn, 2007).

Feed intake, weight gain and feed conversion efficiency (FCE) in lactating buffaloes

There was a significant difference ($p<0.05$) in daily feed intake of buffaloes fed two treatment diets during the study period (Table 4). Daily feed intake of buffaloes fed chopped Guinea grass was significantly higher ($p<0.05$) than buffaloes fed TMR. This was in agreement with the results of Miller-Cushon and DeVries, (2009) and Felton and DeVries, (2010) who observed lower ($p<0.05$) feed intake with TMR feeding compared to conventional feeding. They concluded that high moisture percentage in TMR reduce the feed intake compared to the conventional diet. However, Fan *et al*.,(2002) and Naik *et al*., (2009) reported similar feed intakes in cows and buffaloes, respectively, with TMR *vs*. conventional feeding. However, Verma *et al*., (1996), Kolver and Muller, (1998), Bargo *et al.* (2002), Khan *et al*.,(2010) and DeVries and Gill, (2012) reported increased feed intake in TMR fed cows and buffaloes compared to conventional feeding due to high palatability and the reduced particle size of TMR.

The effect of TMR feeding on body weight of lactating buffaloes was recorded at weekly intervals and presented in **Error! Reference source not found.**. There was a significant difference ($p<0.05$) in body weights and body weight gains of lactating buffaloes fed two treatment diets during the experimental period. Average body weight of buffaloes fed TMR was significantly higher ($p<0.05$) than buffaloes fed conventional feeding. The results of the present study were in agreement with Maltz *et al.*, (1992), Kolver and Muller, (1998), Bargo *et al.*,(2002), Schroeder *et al.*, (2005) and Lailer *et al.*,(2010). They also observed higher body weights of the animals fed on TMR than those fed with concentrate and roughage separately.

Average feed conversion efficiency was significantly higher ($p<0.05$) in the lactating buffaloes fed with TMR compared to the Buffaloes in conventional feeding group (**Error! Reference source not found.**). These results were in agreement with Lailer *et al.*, (2010), Gaafar *et al.*, (2009) and Garg *et al.*, (2013) who observed increased feed conversion efficiency with feeding TMR compared to conventional feeding.

Cost-Benefit Analysis

Table 5 shows the cost-benefit analysis of the experiment. The labour cost for two treatments was similar and also cost for medication and other management practices were similar for the two treatments. The total feed cost for TMR was estimated as LKR.313.76 per animal, per day. In

Table 5: Cost-benefit analysis for lactating buffaloes fed with total mixed ration and chopped Guinea grass

Parameter	Treatment	
	Total mixed ration	Conventional feeding
Feed cost (LKR)	119.28* + 194.48	220.28*
Income (LKR)	343.18	186.74
Profit (LKR)	29.42	-33.54

*Assumption: the price of 1 kg of grass is LKR 5.80 (V.S.K Farms, Andhra Pradesh, India (2.5 Indian rupees/tons of grass)

conventional feeding, feed cost was nearly 220.20 rupees. The total income gained by selling of milk of animals fed TMR and chopped grasses were LKR 343.18 and LKR 186.74 animal per day, respectively. Therefore, a higher profit was reported from feeding TMR. As reported above, average milk yield was higher in the lactating buffaloes fed with TMR compared to the Buffaloes in the conventional feeding group. By the increased milk yield, it positively effects the economic efficiency of the animal.

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