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Effect of total mixed ration (TM R) briquettes on milk yield, composition and sensory properties of cow milk

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ABSTRACT

The current study aimed to assess the effect of feeding total mix ration (TMR) briquettes on milk composition, yield and sensory attributes. Jersey × Sahiwal crossbred cows (Nine) were randomly assigned to three treatments (CTL: guinea grass with commercial feed, TMR1 and TMR2: TMR briquettes) in a 3 × 3 replicated Latin square design. Daily milk yield was recorded and milk composition was measured at three days intervals. At the end of each period, fatty acid composition, calcium, phosphorus and sensory properties of milk were analysed. Milk yield trended to be higher in cows fed with TMR briquettes and milk fat content was similar among the treatments. There was no significant difference in milk fatty acid profile among the treatments; however, lauric acid (C12:0) concentration was significantly higher in milk obtained from the cows fed with TMR1 briquettes. Milk calcium and phosphorus contents did not show any significant difference. All the sensory attributes were significantly higher in milk tested from cows fed with TMR1. The present study revealed that feeding TMR1 briquette could be one of the strategies to overcome the inconsistent milk yield reported during the forage scare periods without affecting the milk composition, and fatty acid composition with better sensory attributes.

Keywords: Fatty acids, Lactating dairy cows, Milk yield, Sensory properties, TMR briquettes

Milk yield and composition are economically important for milk producers and processors. Hence, dairy producers are highly cautious on factors affecting milk yield and composition which has a direct impact on profit. Cow nutrition is one of the key factors which influence milk composition and nutritional changes in the diet of dairy cows can readily alter the fat and protein content of milk (Alothman *et al*. 2019). The fatty acid profile of milk which is of great concern among consumers can also be altered by manipulations of the cow ration (Singh *et al*. 2018). The changes in milk nutrient contents due to various feeding regimens may also lead to alterations in the functional and sensory properties of dairy products (Alothman *et al*. 2019). Therefore, a good feeding management system is essential for the higher production performance of dairy cows ensuring the acceptable quality in milk.

Under the Sri Lankan context, the lack of quality feed resources for dairy cattle has been identified as one of the major constraints in the dairy industry (Vidanarachchi *et al*. 2019). Dairy farmers in the dry zone of Sri Lanka face greater difficulties due to the unavailability of a continuous supply of quality feeds throughout the year. The introduction of a formulated TMR for feeding dairy cows could be a potential way to ensure optimum cow nutrition (Premarathne and Samarasinghe 2020). The preparation of TMR as a briquette is one of the latest developed forage preservation methods in Sri Lanka and it provides the required level of balanced nutrients for the forage shortage period (Karunanayaka *et al*. 2021). Moreover, these TMR briquettes can be formulated with less cost and have a higher shelf life compared to conventional TMR (Karunanayaka *et al.* 2021). It was revealed that feeding TMR briquettes improve forage digestibility (Karunanayaka *et al.* 2022) which might affect the milk yield, composition and sensory attributes of milk. Therefore, the current study aimed to assess the effect of feeding TMR briquette on milk composition, milk yield and milk sensory attributes.

MATERIALS AND METHODS

The feeding trial was conducted from January to April 2021 at the Livestock Farm, Faculty of Agriculture, Rajarata University of Sri Lanka located at longitude 80.4160°E and latitude 8.3726°N. The weather data shows that the average mean rainfall, environmental temperature and relative humidity were 90.10 mm, 26.98°C and 70.98%, respectively. The experiment was approved by the Animal Ethics Committee, Faculty of Veterinary Medicine

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and Animal Science, University of Peradeniya, Sri Lanka (VERC-19-09).

Experimental design and animal management: Nine Jersey × Sahiwal crossbred cows (average body weight 275±33 kg) were randomly assigned to treatments according to a replicated 3×3 Latin Square Design (LSD). Cows were at third parity and early lactation when the experiment commenced. A 14-d of adaptation to the farm environment was allowed before the experiment. Each experimental period consisted of 14-d preliminary period for treatment adaptation and 21-d for the data collection. Between each period, there was a 14-d wash-over period.

Treatments: Three different isocaloric treatments were used to fulfil the dry matter (DM) and metabolizable energy (ME) requirements of cows. The diets were provided as-fed basis and crude protein (CP) and ME were balanced according to the NRC (2001) recommendations. The ingredient and nutrient composition of treatment diets are presented in Tables 1 and 2, respectively.

Table 1. Ingredient composition % of treatments diets[1] (DM basis)

Ingredient	CTL	TMR1	TMR2
Gliricidia (*Gliricidia sepium*)		8.5	11
Guinea grass (*Panicum maximum*)	65	21.5	14
Maize (*Zea mays*)		16	11
Napier grass[2]		13	19
Sorghum (*Sorghum bicolor*)		13	21.5
Rice (*Oryza sativa)* bran		10	6.5
Ground maize (*Zea mays)*		2.5	07
Soybean (*Glycine max)* meal		2.5	03
Coconut (*Cocos nucifera)* poonac		11	05
Mineral mixture		02	0
Dicalcium phosphate		0	02
Commercial cattle feed	35		

Source: Karunanayaka *et al*. (2021). [1]CTL, Conventional diet (Guinea grass + commercial cow feed); TMR1 and TMR2, total mixed ration briquettes made of dried and chopped forages. [2]*Pennisetum purpureum* × *Pennisetum americanum.*

TMR briquettes were prepared using a hydraulic briquette press machine (Green Pack 09, Christo, Katana, Sri Lanka) and the height, width and weight were 50 cm, 30 cm, 30 cm and 10.4 kg (as-fed weight), respectively.

An amount of 9.3 kg DM was offered to each cow twice per day at 08:00 h and 16:00 h as equal portions. Water and feeds were provided *ad lib.* during the study. Dry matter intake and nutrient intake of treatments are given in Table 2.

Milk yield and composition: Machine milking was employed twice a day at 06:00 h and 15:00 h, and milk yields were measured separately for each cow. Milk samples were collected for the milk composition analysis at 3-d intervals, refrigerated (-4°C) without adding any preservatives. Composition parameters and physical properties were analysed using an automated milk analyser (Lactoscan SP, Bulgaria). A representative milk sample from each cow was stored at -18°C to analyse the fatty acid profile.

Table 2. Nutrient composition and intake of control diet and total mixed ration (TMR) briquettes

Parameter	Treatments[1]		
	CTL	TMR1	TMR2
Nutrient composition (%)			
Dry matter	25.6±2.12	88.9±1.40	88.6±1.07
Ash	13.3±0.59	11.1±1.68	11.1±2.68
Crude protein	9.43±0.88	11.6±1.06	11.5±1.00
Acid detergent fibre	43.8±3.21	34.5±2.34	38.7±2.58
Neutral detergent fibre	52.7±3.70	48.8±3.30	48.6±2.66
Calcium	0.95±0.07	0.77±0.11	0.40±0.02
Phosphorous	0.65±0.06	0.79±0.09	0.34±0.05
Dry matter and nutrient intake (kg/d)			
Dry matter	6.8±0.75	7.06±0.75	6.99±0.58
Ash	0.92±0.11	0.78±0.14	0.77±0.19
Crude protein	0.64±0.07	0.82±0.10	0.80±0.09
Acid detergent fibre	2.98±0.39	2.44±0.25	2.71±0.29
Neutral detergent fibre	3.58±0.46	3.45±0.49	3.40±0.32

Source: Karunanayaka *et al*. 2022. [1]CTL, Conventional diet; TMR1 and TMR2, total mixed ration briquettes made of dried and chopped forages.

Analysis of fatty acid profile: Fat extraction was performed as outlined by Mazhitova *et al*. (2015) with a few modifications. Accordingly, frozen milk samples were thawed up to room temperature and 15 mL of samples were centrifuged for 30 min under the 1200 g (Labnet Int-C406490, USA). After the layer separation, milk fat was collected into Eppendorf tubes. Using extracted milk fat, fatty acid methyl esters (FAME) were formulated, transferred to gas chromatography (GC) vials and stored at 4°C until analysis. These FAME samples were analysed by GC-2010 gas chromatography with a MS-QP2020 mass spectrometry detector (GCMSInsight SW Package QP, Japan) to determine the fatty acid profile.

Analysis of calcium and phosphorus: Milk samples were digested and stored at 4°C until analysis. Milk calcium and phosphorus were analysed as described by Jastrzębska (2009) and total phosphorus was analysed using an atomic absorption spectrophotometer (LABOMED, USA) and total calcium was analysed using an inductive coupled plasma optical emission spectrophotometer (Icpap7400 Duo MFC, USA).

Sensory evaluation: Sensory evaluation was conducted at end of the collection period at each phase of 3×3 LSD. The milk samples were pre-heated and cooled until room temperature before the sensory evaluation. The sensory attributes (colour, odour, taste, mouthfeel and overall acceptability) were evaluated according to the nine points hedonic scale by thirty untrained panellists.

Statistical analysis: Treatment effects on milk yield and milk composition were determined using the MIXED procedure of SAS (version 9.0, SAS Institute Inc., Cary, NC). Means were separated using Tukey's Studentized Range Test (TSRT) and statistical significance was used as $p<0.05$. Sensory evaluation data was analysed using Friedman non-parametric method in MINITAB 16 software

(2016) with a 95% confidence interval.

RESULTS AND DISCUSSION

Mik yield: The milk yield of cows was not significantly different ($p>0.05$) among treatments (Table 3). However, cows fed with TMR briquettes showed an increasing trend ($p=0.09$) in milk yield compared to the control. Sarker *et al.* (2019) recorded that cows fed with TMR blocks produce more milk (3.6 L/day) compared to the cows fed with Napier with concentrate mixture (3.35 L/day) which also agreed with the present study. Haloi *et al.* (2020) also observed higher milk yield in cows fed with complete feed blocks and TMR than in cows fed on conventional feed. The average milk production of a cow reared in the dry zone of Sri Lanka, is around 2.1 L/day. When cows are fed with low-quality feeds, they do not have enough energy to maintain their body conditions, resulting in poor milk production. However, providing TMR briquettes in the present study proved that even at feed scare periods, it is possible to maintain quite higher milk production. A greater CP intake and the DM digestibility of cows fed with TMR briquettes compared to CTL (Karunanayaka *et al.* 2022) may contribute to the increasing trend of milk yield observed in the present study. Further, the accounted feed costs per day when feeding TMR1, TMR2 and control were LKR 228.63, 229.17 and 445.33, respectively. With the milk sale at LKR 70/L, the earned profit from feeding TMR briquettes was around LKR 200 per day per cow while there was a loss when feeding the cows with the control diet.

Table 3. Milk yield and composition variation of cow milk after feeding animals with three different rations

Parameter	Treatments[1]			SEM[2]	p value
	CTL	TMR1	TMR2		
Milk yield, (L per cow/day)	5.55	6.59	6.04	0.56	0.0919
Fat (%)	3.84	3.45	3.76	0.21	0.3540
Density (g cm^{-3})	1.028	1.029	1.029	0.00	0.2762
Lactose (%)	4.53	4.59	4.63	0.05	0.1379
Solids non-fat (%)	8.32	8.48	8.44	0.07	0.2088
Protein (%)	3.07	3.07	3.14	0.03	0.2743
Freezing point (°C)	-0.52	-0.52	-0.54	0.01	0.4523
Salt (%)	0.68	0.68	0.68	0.01	0.2741
Calcium (µg/g)	228.29	200.86	202.83	19.86	0.5680
Phosphorous (µg/g)	469.87	456.31	453.09	29.99	0.9144

[1]CTL, conventional diet; TMR1 and TMR2, total mixed ration briquettes made of dried and chopped forages. [2]SEM, standard error of the means.

Milk composition: The tested parameters were not significantly different ($p>0.05$) among the treatments (Table 3). Petters (2018) reported that the forage particle size influences the milk fat content. In the present study, grasses were chopped and concentrates were in powdered form. Hence, particle size can be identified as a combination of coarse and fine particles in all three treatments. Further, the same breed was used in this research and they were in the same lactation stage. Therefore, it might be a possible reason for having similar milk fat contents among the treatments. Previous studies showed that the lactose content in milk was not different when complete feed blocks or TMR and conventional feed were fed to cows (Teshome *et al.* 2017, Petters 2018, Sarker *et al.* 2019, Haloi *et al.* 2020). The average lactose % of the present study was much similar to the values reported by Mohammad *et al.* (2017). Haloi *et al.* (2020) revealed that, SNF % of milk was similar in cows fed on complete feed blocks, TMR and conventional feed which is similar to the present findings.

Rego *et al.* (2016), Teshome *et al.* (2017), Petters (2018), Sarker *et al.* (2019) and Haloi *et al.* (2020) also stated that the milk protein content was not affected by feeding feed blocks or TMR or pasture. Further, previous research studies identified that milk protein content was not affected by dietary protein content during the early lactation period (Gulati *et al.* 2018). In the present study, CP and ME contents were similar and the cows were all in the same lactation stage. Thus, milk protein content might not change among the treatments.

In the present study, the average Ca values in milk were lower than previously reported values (516 µg/g) by Gulati *et al.* (2018). Milk Ca and P contents are largely governed by genetic factors while diet has less impact. Therefore, in the present study, calcium and phosphorous

Table 4. Fatty acid profile in milk fat of dairy cows fed with different rations

Fatty acid, g/100 g FA	Treatments[1]			SEM[2]	p value
	CTL	TMR1	TMR2		
Saturated fatty acids					
C8:0	0.68	0.74	0.82	0.09	0.4209
C10:0	1.40	1.40	1.45	0.16	0.9552
C12:0	2.41[b]	3.91[a]	3.32[a]	0.28	0.0021
C14:0	8.11	9.15	8.70	0.36	0.1353
C15:0	1.28	1.03	1.07	0.07	0.0575
C16:0	27.26	25.26	25.30	0.82	0.0694
C17:0	0.85	0.65	0.73	0.05	0.0171
C18:0	16.57	17.43	18.37	0.96	0.3948
C19:0	0.55	0.55	0.54	0.03	0.9197
C20:0	1.06	0.85	0.92	0.06	0.0665
Mono-unsaturated fatty acids					
C14:1	0.85	0.74	0.87	0.12	0.7418
C16:1	1.60	1.38	1.29	0.13	0.2775
C17:1	0.38	0.30	0.30	0.03	0.0718
C18:1	29.89	30.35	29.45	0.86	0.7406
Poly-unsaturated fatty acids					
C18:2	0.53	0.34	0.44	0.06	0.0816
C18:2 t	1.66	1.44	1.45	0.09	0.1560

[1]CTL, conventional diet; TMR1 and TMR2, total mixed ration briquettes made of dried and chopped forages. [3]SEM, standard error of the means. [a, b]Mean values were significantly ($p<0{\cdot}05$) different within the row across treatments.

contents in milk also did not show any significant changes among treatments mainly because of the similar breed, parity and lactation stage of cows.

Fatty acid profile of milk: There was no significant ($p>0{\cdot}05$) difference among the treatments except for lauric acid (C12:0) (Table 4). Morales-almara *et al*. (2010) reported that TMR-fed animals had 2.28 g/100 g of C12:0 which was lower than the present study. It might be due to the variation in ingredient composition of TMR. Rego *et al*. (2016), observed an association between the concentration of C12:0 and TMR diet. Their findings agreed with the present study results. Milk fatty acid was synthesised by using precursors produced by bacteria in the rumen, dietary lipids, and the lipolysis process in adipose tissue and factors such as animal genetics, stage of lactation, diseases, rumen fermentation, dietary factors and seasonal variation could influence the fatty acid composition (Mansson 2008).

Sensory attributes of milk: The sensory attributes such as colour, odour, taste, mouthfeel and overall liking were significantly ($p<0{\cdot}05$) higher in milk received from cows fed with TMR1 compared to other treatments (Fig. 1). Long-chain fatty acids contribute an indirect effect on milk flavour; since they could be hydrated, oxidized, or reduced to odour-active compounds. The grassy flavour was higher in cow milk when fed with a pasture diet than the TMR

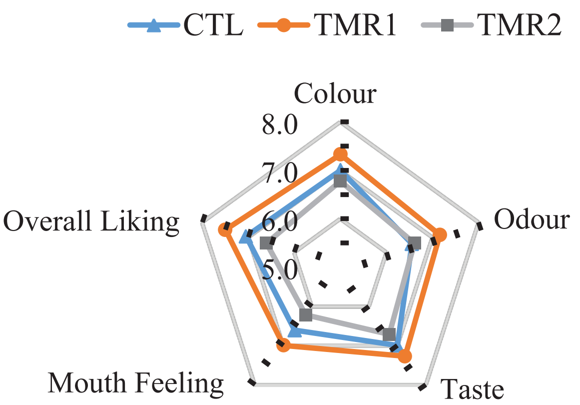

Fig. 1. Variation of sensory attributes of milk from cows fed with control feed and TMR briquettes. CTL, conventional diet; TMR1 and TMR2, total mixed ration briquettes made of dried and chopped forages.

which contains more esters, acids, and phenols (Villeneuve *et al*. 2013, O'Callaghan *et al*. 2017). Even though these long-chain fatty acids were not tested in the present study, it could be the reason for the higher taste recorded for milk from cows fed with TMR1 compared to the control.

The fatty acid profile also influences the texture of both milk and dairy products (Kilcawley 2019). The presence or absence of double bonds directly influences the melting point of fat which affects the texture of milk (Siram *et al*. 2019). Colour is one of the sensory properties that influence on quality, consumer acceptance of milk and dairy products. Milk from grass silage-fed cows produce more yellow colour than grass hay-fed cows; since hay was in dry form and already lost the pigments (Martin *et al*. 2005). Briquettes were formulated with dry forage particles and thus the current study also confirmed that diet has a direct effect on milk colour.

The total mix ration briquettes trend to increase milk yield and feeding total mix ration briquette 1 produces 20% more milk yield compared to the control. However, milk composition and milk fatty acid profile except lauric acid are not influenced by feeding total mix ration briquettes. The milk taken from cows fed with total mix ration briquette 1 attracts more consumers due to better sensory properties. Hence, the present study confirms that the use of total mix ration briquette 1 could be a possible strategy to overcome the inconsistent milk yield reported during the forage scare periods in Sri Lanka and guarantees additional profit compared to a pasture-based diet.

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