EFFECT OF TWO DIFFERENT TOTAL MIXED RATIONS (TMR) ON THE PRODUCTION PERFORMANCE OF MILKING COWS

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Abstract

A major constraint faced by dairy farmers in intermediate zone is the severe drop in body condition score and milk production in dry periods due to scarcity of quality feeds. A study was undertaken to evaluate the effect of an introduced total mixed ration (iTMR) vs the grass based existing total mixed ration (eTMR) on the production performances of milking cows. Eighteen, Frisian x Jersey crossbred lactating cows were randomly assigned into two treatments with three replicates each (T1: eTMR and T2: iTMR), in a Randomized Complete Block Design (RCBD). Daily feed intake, milk yield and live weight of animals were recorded. Results showed that, crude protein and ether extract contents in iTMR were higher ($P < 0.05$) than eTMR. Average milk yield was higher ($P < 0.05$) in the cows fed with iTMR compared to eTMR. The average solid non-fat (SNF), milk fat and protein contents were significantly greater ($p < 0.05$) in iTMR fed group compared to eTMR fed group. The cost-benefit analysis suggested that iTMR fed cows contributed to a high income compared to those fed with the eTMR. Findings of this study showed that iTMR formulated using locally available ingredients is cost effective which enables profit maximization.

Keywords: *Dairy cows, Milk composition, Milk yield, Profit, Total Mixed Rations*

INTRODUCTION

During drought periods in the intermediate zone of Sri Lanka body condition of dairy cows drops as a result of the feed scarcity (Ibrahim & Jayatilaka, 2000). Most of the time, the diet is neither consistent nor nutritionally balanced. When the dairy cows are reared only on pasture based diets the crude protein content can be high and the energy content is lower in the diet. This imbalance in protein to energy levels consequently decrease the milk production (Schären et al., 2016). Accordingly, high producing cows cannot be reared only on pasture as it would cause a severe loss in live weight and drop in milk yield (Hernández-Ortega et al., 2014). Supplementing forage feeding with concentrates or feeding a total mixed ration (TMR) with high quality forages is one of the remedial measures to this situation. TMR allows mixing of all feed ingredients i.e. roughages and concentrates together, based on a prescribed amount of each ingredient. Thus, it allows animal to receive a nutritionally balanced diet with no selection of individual ingredients (Nissanka et al., 2010). It is important to have the recommended energy to protein balance in the formulated TMR if the aim is to increase the milk production (Kolver & Muller, 1998). As described by Mohammad et al. (2017), TMR is a complete feed formulated with concentrates and roughages according to the cow's live weight and milk production and is fed *ad libitum*. It prevents the fluctuation of rumen pH and enhances a favourable rumen environment for the microbes compared to conventional feeding (Coppock et al., 1981). However, a TMR may not cover all

the nutrient requirement of a high yielding cow. Therefore, an extra supplementation of concentrates in TMR would be beneficial to overcome ruminal problems caused by high and separate concentrate usage in high yielding cows (Mohammad et al., 2017).

The ingredients in the formulated TMR are known and it is offered as the sole diet (Amaral-Phillips & Turner, 2002). By blending all the ingredients such as forages, grain, oil meals, mineral and vitamin supplements together, avoid the cows to have any selection. Further the mixing of ingredients removes the undesirable flavours in less palatable feeds (Amaral-Phillips & Turner, 2002). Farmers use different TMR mixes to feed dairy cows in Sri Lanka. Most of these TMR are not up to the nutritional standards recommended by National Research Council (NRC, 2001). Hence these TMR can be just mixed rations.

A private farm at the intermediate zone rears Frisian x Jersey crossbred cows which were imported in 2014 from Australia. These cows were stall-fed with a grass based mixed formulated ration twice per day. However, the expected milk yields were not obtained. It may be due to the sudden change of environment due to importation, in addition to the change in diet/ration and the management conditions. Owing to the marginal profit drawn in farming activities, the sustainability of the farm is at a question. Thus, a study was undertaken at the farm to evaluate the effect of an introduced total mixed ration (iTMR) vs the existing total mixed ration (eTMR) with the hypothesis that the iTMR will improve the milk yield compared to eTMR.

MATERIALS AND METHODS

Preparation of Rations

A feeding trial was undertaken from December 2018 to February 2019 at a private dairy farm at Mawathagama (7.4322° N, 80.4438° E, altitude 66 m), Sri Lanka. The quality of the feed ingredients of the total mixed ration used in the farm (eTMR) was analysed according to AOAC, (2001). A new total mixed ration (iTMR) was formulated to avoid the imbalances in the eTMR based on the NRC recommendations (NRC, 2001). Thus, the iTMR was formulated by incorporating supplementary ingredients to the eTMR. The composition of both iTMR and eTMR are given in the Table 1. Both rations were prepared on daily basis for the feeding trial.

The crude protein (CP) content and metabolizable energy (ME) content of eTMR were 14% and 2603.9 kcal/kg, respectively. Introduced mixed ration (iTMR) was formulated to have 15% CP content and 2600.0 kcal/kg metabolizable energy (ME) content according to NRC (2001) standards. The above CP and ME contents were maintained in two rations throughout the experimental period. The metabolozable energy was calculated according to the procedures given by Fonnesbeck at el., (1984);

Total Digestible Energy (TDN) =
40.23+0.1969(CP)+0.428(NFE)+1.19(EE)-0.1379(CF), and

ME (kcal/kg) = TDNx0.03615.

Table 1: Composition of the two Total Mixed Rations (TMRs)

Raw ingredient	Composition of eTMR		Composition of iTMR	
	As fed basis (%)	DM basis (kg)	As fed basis (%)	DM basis (kg)
Chopped maize (*Zea mays*) fodder (without cobbs)	55.5	7.0	10.0	1.0
Chopped CO3 (*Pennisetum perpureum X Pennisetum americarnum*)	13.8	1.0	25.0	2.0
Chopped guinea grass (*Panicum maximum*)	-	0	20.0	2.0
Cattle feed	11.1	4.0	-	0
Beer pulp (wet brewer's grain)	11.3	1.0	4.0	0.5
Dhal (*Cajanus cajan*) dust	5.6	1.0	-	0
Coconut (*Cocos nucifera*) poonac	-	0	20.0	7.0
Rice (*Oryza sativa*) bran	-	0	10.0	3.0
Maize meal	-	0	10.0	3.0
Mineral mixture	2.8	2.8	1.0	1.0
Vitamin & mineral mixture*	50g/cow	50g/cow	50g/cow	50g/cow
Total	100%	16.8 kg	100%	19.5 kg

* Vitamin & mineral mixture - Milk Magic (Agro Nutrition Pvt Ltd, Mt Lavinia, Sri Lanka) at a cost of Rs 175.00 per one kg

Experimental animals and set up

Eighteen, Frisian x Jersey crossbred cows (at the age of 3.5 years with mean (± SE) body weight, Body Condition Score and milk yield of 418 ± 13 kg, 2.7 ± 0.05 and 9.5 ± 4.12 litres, respectively) in their first parity were randomly assigned into two treatment groups (T1: eTMR and T2: iTMR), in a Randomized Complete Block Design (RCBD). There were three replicates per treatment and each replicate had three cows. The blocks were arranged according to body weight of cows and there were two blocks in the design. Hence altogether there were nine cows per treatment. The cows were stall fed *ad-libitum* twice a day; at 5.30 h and 17.00 h, and machine milked twice a day; 3.30 h and 15.30 h. The cows were given a preliminary period of 7 days to adapt to the iTMR and data were collected for 5 weeks afterwards. Water was freely available for the cows throughout the experimental period. The cow shed is a free stall barn with concrete floor and manure was scrapped three times a day into a sedimentation tank.

Sampling and sample preparation

Representative feed samples were randomly collected from eTMR and iTMR at each preparation time (twice a month). The samples of each treatment at each preparation time were pooled, dried and ground to pass through a mesh (1mm) and this pooled sample was stored in a sample bottle until use for analysis. The stored samples were analysed for proximate composition as per the standard procedures (AOAC 2001). Accordingly, crude protein (CP) was determined using Kjeldahal procedure (DK 20, Italy) and the crude fibre (CF) was determined using fibre analyser (FIWE3, Italy). Ether extract (EE) and ash contents were determined using Soxhlet apparatus and the Muffle furnace respectively.

Feed intake and body weight

Daily feed intake was recorded on fresh matter basis by weighing the feed offered and refused during the experimental period. The feed intake was calculated in both fresh and dry matter basis. Live body weight of each cow was taken at the beginning of the trial and at two weeks interval (before feeding) by using a weighing band (China Co. Ltd 1986). The average of three body weight readings were taken in each cow to increase the accuracy of measurement. According to the feed intake, daily feed cost was calculated using the unit price spent for purchasing of raw materials. The cost for labour was similar for both type of TMR preparations.

Milk yield and composition

Milk yield was recorded daily at morning and evening milking times. Daily milk yield of each animal was measured by using an automated measuring system installed at the farm. Four milk samples were obtained during the five week period from each cow to determine the milk composition (protein, fat and solid non-fat) by using lacto scanner (Bulgaria) at Cargill's Milk Chilling Centre, Kurunegala.

Body Condition Score (BCS) of cattle

Body condition score was visually estimated four times during the five week period according to 1-5 point scoring system.

Feed conversion efficiency (FCE)

Feed conversion efficiency was calculated using the following formula.

$$FCE = \frac{\text{Total milk yield (litres per day)}}{\text{Dry matter intake kg per day}}$$

Cost estimates

Costs incurred for both iTMR and eTMR preparations were estimated and compared.

Data analysis

Data related to live weight, body condition score, milk yield, composition of milk, feed intake and feed conversation efficiency were analysed using randomized block design employing proc GLM using SAS, (2002). Nutrient data (CP, CF, EE, Ash) were analysed using one-way ANOVA in SAS, (2002). The means were separated using LSD procedure in proc GLM.

RESULTS AND DISCUSSION

Nutrient content of two TMRs (eTMR and iTMR)

As shown in Table 2, the total ash, crude fibre and crude protein contents of the two TMR preparations were not significantly different ($P > 0.05$). However, ether extract content (EE) in iTMR was higher ($P < 0.05$) than that of the eTMR. The inclusion of coconut poonac (22% CP and 11% EE), maize meal (10% CP and 3% EE) and rice bran (10.5% CP and 7% EE) may have contributed to the increase in EE% in iTMR (Ibrahim, 1988; Jurgens et al., 2012).

Table 2: Nutrient composition and feed intake of eTMR and iTMR on DM basis.

Treatment	Nutrient composition % Dry Matter basis (means ± SE)*				Feed Intake (kg/day/cow) (means ± SE)*	
	Ash	CP	EE	CF	As fresh basis	DM basis
eTMR	10.5 ± 1.2	14.4 ± 0.7	11.6^{b} ± 0.6	47.3 ± 3.8	33.7^{b} ± 0.1	18.6^{a} ± 0.2
iTMR	13.0 ± 1.0	16.3 ± 0.6	16.2^{a} ± 0.5	53.1 ± 3.1	34.8^{a} ± 0.1	16.7^{b} ± 0.2

* Means within the same column with different superscripts are significantly different (P < 0.05). CP: crude protein, EE: ether extract and CF: crude fibre

Feed Intake

Cows were in good health throughout the study period and eTMR and iTMR were well accepted by the cows. Daily feed intake on dry matter basis with cows fed with eTMR was significantly higher (P < 0.05) than that of cows fed with iTMR (Table 02). According to Felton & Devries, (2010) the lower feed intake with TMR feeding may be due to the high moisture percentage in TMR. In the present study moisture content of iTMR (50±1.63%) was higher (P < 0.05) than that of eTMR (48±1.63%). Thus, the high moisture content may have reduced the feed intake in iTMR. However, Khan et al., (2010), Kolver and Muller, (1998) and Vries and Gill, (2012) reported that the feed intake of TMR is generally high compared to conventional feed due to the high palatability and the reduced particle size of TMR.

Effect of Treatment on Milk Yield and Composition

Milk yield

There was a significant difference (P< 0.05) in daily average milk yield of cows fed with iTMR and eTMR during the study period (Figure 1; Table 3). Average milk yield was significantly higher (P< 0.05) in the cows fed with iTMR than that in cows fed with eTMR after the 3rd week of onwards. According to Bargo et al. (2002) the cows under intensive management on TMR does not have energy maintenance related to walking and grazing. Thus, the energy cost is less compared to a cow on pasture. Hence, the saved energy has increased the activity and resulted a higher milk production on TMR fed cows (Kolver & Muller, 1998; Kolver et al., 2000; Bargo et al., 2002). In the present study, the difference between two TMR could be due to the composition of the mixes. Even though both iTMR and eTMR were balanced for CP and ME according to NRC (2001) i.e 15% CP and 2530 kcal/kg ME, the variation in ingredients may have contributed to the significant increase in milk yield in iTMR.

Milk composition

A significantly high (P< 0.05) milk fat content was observed in cows fed with iTMR compared to cows fed with eTMR (Table 3). Initially the ether extract was higher in the iTMR than in eTMR (Table 2). This observation may be due to the inclusion of fat containing feed ingredients such as coconut poonac, maize meal and rice bran as observed by Harvatine et al., (2009) who concluded that fat content in milk could vary significantly due to nutrition. Supporting the above finding Mohammad et al., (2017), reported that cows fed on TMR had higher (P < 0.05) total milk fat percentage than feeding concentrate and roughages separately. Similarly, Bargo et al., (2002) reported that cows fed on TMR produced more fat in

milk than cows on fed pasture. The fat level in the ration (contributed from both roughages and concentrates) may have had a positive impact on the fat levels in milk in the present study. Even though the crude protein contents were similar in both rations, SNF and protein content of milk were significantly greater ($P < 0.05$) in iTMR fed group compared to eTMR fed group. The iTMR was prepared considering the initial live weight and milk yield according to the NRC (2001) recommendation. Hence in overall, the positive effects of iTMR on milk yield and composition show that the iTMR has given the required levels of nutrients to the cows as expected.

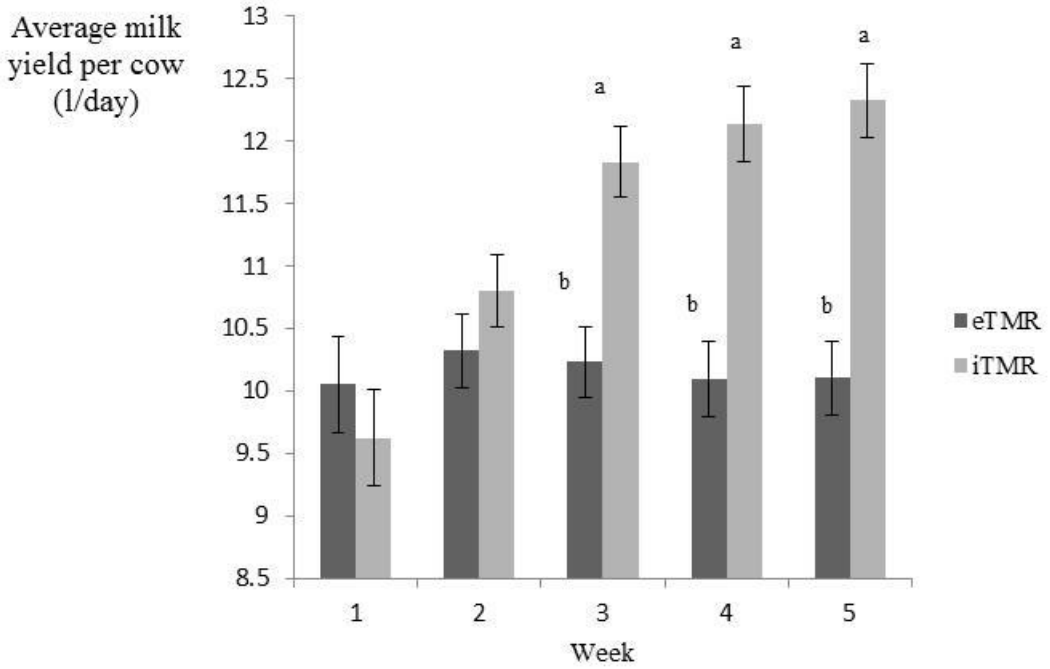

Figure 1: Average milk yield per cow (l/day)

Table 3: Variation of milk yield (L/ cow) and composition of milk (Mean ± SE)*

Parameter	iTMR	eTMR
Milk yield (L per cow)	$12.0^{a} \pm 0.24$	$10.2^{b} \pm 0.24$
Milk composition (%)		
Fat	$4.86^{a} \pm 0.00$	$4.54^{b} \pm 0.00$
SNF	$9.05^{a} \pm 0.00$	$8.84^{b} \pm 0.00$
Protein	$3.65^{a} \pm 0.01$	$3.41^{b} \pm 0.01$

* Means within the same row with different superscripts are significantly different ($P < 0.05$).

Body weight, body condition score (BCS), Feed intake and Feed conversion efficiency (FCE)

There was no significant difference ($P > 0.05$) in body weight, body condition score (BCS) and feed conversion efficiency of cows fed either with iTMR or eTMR (Table 4). Cost of feed ingredients was the main cost of preparation for both TMR (Table 5) as the ingredients were all purchased. It was high in eTMR. The main cost for eTMR was for fodder maize (55%), cattle feed (13%), beer pulp (11%) and dhal dust (5.6%), all of which were costly ingredients. Cost of feed ingredients for iTMR, (CO3 (25%), guinea grass (20%), coconut poonac (20%), rice bran (10%) and maize meal (10%)) were comparatively less costly. Labour cost involved for mixing the ingredients was considered same for both groups. The income which was obtained from sale of milk was higher in the iTMR group compared eTMR fed group. Thus, feeding the iTMR was profitable compared to feeding the existing TMR. It was mainly due to the increase in the milk production in the cows fed with iTMR compared to the cows fed with existing TMR.

DISCUSSION

The objectives of the present study is to evaluate the effect of an introduced total mixed ration (iTMR) vs the existing total mixed ration (eTMR) with the hypothesis that the iTMR will improve the milk yield compared to eTMR. Countries like New Zealand use TMR only during the winter season whereas some countries totally depend on TMR for feeding dairy cows (Bargo et al., 2002). If the pasture is of quality, especially with high crude protein levels i.e *Lolium perenne* 20% (Jurgens et al., 2012), TMR feeding is not effective. However, feeding TMR has become important in countries like Sri Lanka as the quality and the quantity of the grasses and fodders are not consistent throughout the year (Ibrahim, 1988). Therefore, a balanced diet fed reaching the recommended DMI is important to maintain a consistent milk production throughout the year. However, use of TMR by small-scale livestock farmers in the country is not that common probably due to lack of knowledge (Premarathne & Samarasinghe, 2020). Thus, extension services should be strengthened in order to popularize this feeding system among the smallholder farmers.

Table 4: Body weight, body condition score (BCS) and feed conversion efficiency in cows fed with iTMR and eTMR (Mean ± SE)

Parameter	Treatment	
	iTMR	eTMR
Body weight (kg)	436.7 ± 31.70	409.2 ± 31.70
BCS	2.87 ± 0.00	2.74 ± 0.00
Feed conversion efficiency	0.683 ± 0.00	0.643± 0.00

Table 5: Cost-benefit analysis for cows fed with iTMR and eTMR

Parameter	Treatment	
	iTMR	eTMR
Feed cost (Rs)	542.00	615.50
Income (Rs)	961.60	812.80
Profit (Rs)	419.60	197.30

nutritionally balanced diet enhances optimum fibre digestion and utilization facilitating less fluctuation in rumen pH (Coppock et al., 1981; Mould & Ørskov, 1983). In a pasture based feeding system, where the rumen is filled within a shorter period due to the low digestibility of the feed, reducing the intake (Loerch, 1990). However, TMR feeding avoids selection (Amaral-Phillips & Turner, 2002) and feed wastage as it is formulated to balance the daily nutrient requirement of the cow. Cutting the forage particles to smaller pieces enhances intake and digestion while reducing the time spent on mastication (Nissanka et al., 2010). Both TMR preparations used in the present study contain beer pulp, which is a cheap source of nutrients containing crude protein 22%, EE 12% and total ash 4%, respectively. It was included in the TMR preparation in order to increase the palatability and enhance the rumen environment. The high milk yield obtained from the cows fed with the iTMR may be due to the overall effect of all the ingredients included in the preparation.

Voluntary feed intake is the major limitation in supplying nutrients to dairy cows (Anon 2019). Feed intake is usually characterized as dry matter intake to compare diets with different water concentrations. Factors such as body size, milk yield, lactation period or pregnancy effect on dry matter intake. Dry matter intake ranged usually between 3.5 - 4% of body weight or it can be higher as 5% with the level of production (Anon 2019). In the present study dry matter intake in both preparations of TMR was 4% of body weight which is similar to previous studies (Bargo et al., 2002). Practically, it is difficult to supply all the nutrients required by the dairy cows. However, attention should be paid to fulfil the energy and protein requirements of the animal when formulating a TMR. It would enable to obtain a higher milk production from high producing dairy cows without compromising the BCS. Average BCS was 2.80±0.02 in the present study. Thus, the iTMR which was formulated to overcome the gaps in the eTMR has shown positive results. However, a long term study is suggested to confirm the present findings.

CONCLUSIONS

Feeding new total mixed ration does have a significant impact on milk yield, milk fat, milk solid non-fat of lactating cows under intermediate zone farm condition. Thus, it can be concluded that the farm can maximize the profit by replacing eTMR with the iTMR.

Conflicts of Interest Statement

Authors state that there is no conflicts of interest exist.

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