Original Research

Economics of Production of Lactating Dairy Cows Fed on Paddy Straw plus Non-Forage Fibre Sources Based Complete Rations Containing Different Levels of Neutral Detergent Fibre

Biju Chacko[1*], K. M. Syam Mohan[2], K. Ally[2], K. Shyama[1], K. S. Anil[3] and C. T. Sathian[4]

College of Veterinary and Animal Sciences, Mannuthy- 680651, Thrissur, Kerala, INDIA

[1]Department of Animal Nutrition, College of Veterinary and Animal Sciences, Pookode, Lakkidi, Wayanad, Kerala, INDIA
[2]Department of Animal Nutrition
[3]Department of Livestock Production Management
[4]Department of Dairy Science

***Corresponding author:** bijuchacko@kvasu.ac.in

Rec. Date:	Jan 16, 2019 08:00
Accept Date:	Apr 21, 2019 16:56
DOI	10.5455/ijlr.20190116080018

Abstract

An investigation was conducted to assess the economics of production of lactating dairy cows fed on paddy straw plus non-forage fibre sources (NFFS) based complete rations containing different levels of neutral detergent fibre (NDF). The study was conducted for a period of six months in 18 lactating dairy cows, divided into three groups of six each, by feeding them on paddy straw plus NFFS based complete rations containing different levels of NDF, in two phases of three months (90 days) each, being the early and mid lactation phases, respectively. Three isonitrogenous and isocaloric complete rations, T1, T2 and T3 with 25, 30 and 35 per cent NDF, respectively formulated as per ICAR-NIANP (2013), were fed to the experimental animals. Individual records of daily dry matter intake and milk production were maintained throughout the experiment. From the data gathered on these two parameters, in the two phases, the cost of feed per kilogram of milk produced was worked out. Data gathered on the various parameters, in the two phases were analysed statistically as per Snedecor and Cochran (1994) by analysis of variance (ANOVA) technique, using the software, statistical product and service solutions (SPSS) version 21.0. The cost per kg of milk produced by the cows fed on the three experimental rations; T1, T2 and T3 in phase I, phase II and the total experiment were, Rs. 28.58, 28.50, 29.70; 35.08, 34.05, 33.72 and 31.89, 31.27, 31.73, respectively, with the values in the three dietary treatments being similar (P>0.05). An overall critical evaluation of the results of both the phases as well as the total experiment revealed that the animals in all the three dietary treatments performed well and suggest that complete rations containing paddy straw as the sole source of roughage, with 25 to 35 per cent NDF can be recommended for use among early and mid lactation dairy cows.

Key words: Cost Economics, Complete Ration, Dairy Cows, NDF, Non Forage Fibre Sources, Paddy Straw

How to cite: Chacko, B., Mohan, K., Ally, K., Shyama, K., Anil, K., & Sathian, C. (2019). Economics of Production of Lactating Dairy Cows Fed on Paddy Straw Plus Non-Forage Fibre Sources Based Complete Rations Containing Different Levels of Neutral Detergent Fibre. International Journal of Livestock Research, 9(6), 148-156. doi: 10.5455/ijlr.20190116080018

Introduction

Energy requirements for lactating dairy cows are met from the fibrous and non-fibrous carbohydrate fractions of the diet. To achieve maximum production, dairy rations should be balanced for neutral detergent fibre (NDF), at the same time not compromising on the non-fibrous carbohydrate fractions so that optimum energy intake and rumen health are ensured. National Research Council (NRC) of the United States of America (USA) has recommended that a milking cow should be fed with a ration containing at least 25 to 33 per cent of fibre in the form of NDF (NRC 2001). However, providing even this minimum quantity of fibre, from forage sources alone, is very difficult because, currently in India, green fodder was deficit to the tune of 61.10 per cent (Datta, 2013) and in Kerala, the deficit was 78.02 per cent (Government of Kerala, 2013). In this regard, incorporation of fibre from non-forage sources such as rice bran and coconut cake have to be thought of. NDF from such non-forage sources have got lesser rumen filling effect, is less lignified than NDF from forages, increases the dry matter intake and also the milk yield (Reyya *et al*., 2014). A feasible cattle feeding practice that can hence be adopted is to provide feed in the form of complete diets, which involves processing the concentrate and roughage ingredients together into a well-mixed blend to which the animals are given free access (Owen, 1984). Among the various roughages like grasses and straws, straw has got the highest rate of chewing and hence is most effective when added to complete feeds (Stone, 2004).

Paddy straw can be used as the sole source of forage NDF in complete rations for cows (Sadagopan and Sunder, 1997). Garg (1997) reported that in the Northern states of India, wheat straw was preferred for feeding of livestock while most of the paddy straw was burnt. In Kerala, there are paddy cultivating tracts in each district, from where the straw can be procured in bulk, at prices ranging from Rs. 5.50/- to Rs. 6.50/- per kg (Radha Devi and Ajith Kumar, 2011), which can then be dried, powdered and incorporated into complete feeds. Therefore, the need of the time is to procure paddy straw in bulk, blend it with locally available NFFS like brans and other concentrate ingredients to form a complete feed or complete diet (Lailer *et al*., 2005). Formulation of a paddy straw based complete feed, with minimum amount of forage NDF, with the rest of the NDF being met from non-forage fibre sources (NFFS), is hence a viable feeding practice. However, the optimum level of NDF required to obtain maximum milk production from the cows, in an economical manner has to be studied, so that it can be advised to farmers. Most of the researches done on complete feeds in the western countries are grass based. In India, not much research has been conducted for formulating a paddy straw based complete feed with the optimum NDF level for lactating dairy cows.

DOI 10.5455/ijlr.20190116080018

Therefore, this investigation was carried out to assess the effect of different levels of NDF in paddy straw plus NFFS based complete feeds for cows in early and mid-lactation on the basis of economics.

Materials and Methods

Eighteen crossbred dairy cows in the early stage of lactation (within 2 weeks of calving) were selected from the University Livestock Farm and Fodder Research and Development Scheme (ULF & FRDS), Mannuthy, Kerala. They were divided into three groups of six each, as uniformly as possible with regard to age, parity, milk yield and body weight and were allotted randomly in a completely randomised design to three complete rations, T1, T2 and T3, formulated as per ICAR-NIANP (2013). All the cows were maintained under uniform management conditions prevailing in the farm, with the animals in the three dietary treatments, T1, T2 and T3, were fed with complete rations containing different levels of NDF, *viz.* 25, 30 and 35 per cent, respectively. The rations were made isonitrogenous (12.00 to 13.00 per cent CP) and isocaloric (63 to 65 per cent TDN) and were compared on the basis of feeding trials of total 180 days duration, in two phases of three months each, the first 90 days being the early lactation and the next 90 days being the mid lactation. The ingredient composition and the estimated nutrient content of the experimental rations in the two phases are depicted in Tables 1and 2, respectively.

Table 1: Ingredient composition of complete feeds offered to cows in phases I and II, kg

Ingredient	Phase I			Phase II		
	T1	T2	T3	T1	T2	T3
Maize	37	27	16	38	30	21
Coconut cake (de-oiled)	11	12	17	5	8	12
Rape seed meal	11	12	11	10	10	10
De-oiled rice bran	20	19	16.5	26	23	21
Paddy straw	14	21	29	14	22	29
Molasses	5	5	5	5	5	5
Calcite	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Vegetable fat	-	2	3.5	-	-	-
Total	100*	100*	100*	100*	100*	100*

** To every 1 kg of complete feed, 0.10 g of Vitamin AD$_3$E supplement (containing 10,000 I.U of Vitamin A, 2000 I.U of Vitamin D$_3$ and 1000 I.U of Vitamin E), 0.50 g of trace mineral mixture (KERAMIN FORTE) and 0.50 g of toxin binder (CURATOX) were added*

Proximate principles of feed were determined as per standard procedure of AOAC (2016). The NDF and acid detergent fibre (ADF) were estimated by the detergent method of Van Soest *et al*. (1991). The calcium and phosphorus contents of the feed were analysed as per the standard procedure described in AOAC (2016). Weighed quantities of complete feed were fed individually, on an *ad libitum* basis, to all the animals and the balance feed in the manger was collected manually and weighed, twice a day, in the morning and afternoon at 9 AM and 2 PM, respectively. Samples of the left over portions of the feed were taken daily

 DOI 10.5455/ijlr.20190116080018

for analysing the moisture content and the daily dry matter intake was calculated. The data on daily dry matter intake was recorded during the entire experimental period.

Table 2: Chemical composition of complete feeds offered to cows in phases I and II (% DM basis)

Nutrient	Phase I			Phase II		
	T1	T2	T3	T1	T2	T3
Crude protein	12.23	12.94	12.18	12.4	12.14	12.08
Crude fibre	10.73	12.68	15.01	10.53	12.7	14.85
Ether extract	4	3.6	3.8	4.5	3.5	3.6
Total ash	14	12.9	12.9	14.1	13.3	12.98
Nitrogen free extract	59.04	57.88	56.11	58.47	58.36	56.49
Acid insoluble ash	5.3	5.6	6	4.8	5.4	6.2
NDF	25.88	30.03	35.59	25.94	30.86	35.38
ADF	21.6	23.1	24.8	21.8	23	25.01
Calcium	0.83	0.85	0.87	0.81	0.84	0.86
Phosphorus	0.54	0.52	0.48	0.59	0.55	0.52
TDN*	64.5	64.44	64.28	64.04	63.28	63.25
Metabolisable energy* (MJ/ kg DM)	9	8.87	8.41	9.04	8.54	8.24

** Calculated value*

The animals were milked twice a day. The data on milk yield recorded was used to calculate the daily milk yield for each animal throughout the experimental period. From the data gathered on these two parameters, in the two phases as well as the total experiment, the cost of feed per kilogram of milk produced was worked out. Data gathered on the various parameters, in the two phases were analysed statistically as per Snedecor and Cochran (1994) by analysis of variance (ANOVA) technique, using the software, statistical product and service solutions (SPSS) version 21.0. Homogenous subsets were separated using Duncan's multiple range test, described by Duncan (1955). Differences among treatments were considered to be significant, when $P \leq 0.05$.

Result and Discussion

The data on dry matter intake (DMI), milk yield and cost per kg milk production of cows maintained on the three experimental rations in phases I, II and the total experiment of the experiment are given in Tables 3, 4 and 5, respectively. The DMI of cows fed on the three experimental rations were similar ($P>0.05$) in phases I, II and the total experimental period. Similarity in DMI among early lactation dairy cows fed on different experimental rations, as found in this experiment were also obtained by Weiss and Wyatt (2002) and Kendall *et al*. (2009) in cows fed on complete diets with varying levels of NDF and varying digestibility of NDF of the forage used. Similar DMI in mid lactation cows was reported by Yang and Beauchemin (2005) in cows fed on complete rations with NDF content in the range of 30 to 33 per cent but varying in

 DOI 10.5455/ijlr.20190116080018

physically effective neutral detergent fibre (peNDF) and Neto *et al*. (2014) in cows fed on complete diets based on low as well as high peNDF corn and sugarcane silage.

Table 3: DMI, milk yield and cost per kg milk production of animals maintained on three experimental rations in phase I

Parameter	T1	T2	T3	F-value (p-value)
Total DMI, kg	1010.66 ± 35.75	1082.34 ± 49.01	1108.36 ± 32.33	0.487^{ns} (0.624)
Daily DMI, kg	12.03±0.43	12.89±0.58	13.19±0.38	1.625^{ns} (0.23)
Total milk produced, kg	976.85 ± 42.74	1064.65 ± 61.98	1060.83 ± 54.13	0.519^{ns} (0.605)
Daily milk yield, kg	11.63±0.51	12.67±0.74	12.63±0.64	0.859^{ns} (0.443)
DMI per kg milk produced, kg	1.04 ± 0.03	1.02 ± 0.04	1.06 ± 0.07	0.122^{ns} (0.886)
Total feed intake, kg	1158.35 ± 40.98	1254.17 ± 56.79	1291.8 ± 37.68	2.246^{ns} (0.14)
Cost per kg of feed, Rs.	24	24	24	-
Total cost of feed, Rs.	27800.38 ± 983.46	30099.96 ± 1362.87	31003.09 ± 904.32	2.246^{ns} (0.14)
Cost per kg milk produced, Rs.	28.58 ± 0.96	28.50 ± 1.25	29.70 ± 2.06	0.202^{ns} (0.819)

The milk yield of the animals in all the dietary treatments were similar (P>0.05) in phases I, II and the total experiment. Similarity in milk yield among early lactation dairy cows in the three dietary treatments, as observed in this study was also reported by Weiss and Wyatt (2002) in lactating cows fed on complete diets with varying levels of NDF and varying digestibility of NDF of the forage. Similarity in milk yield, in mid lactation cows, as observed in the present study was found by Depies and Armentano (1995) who reported that addition of NFFS such as ground maize cobs and wheat middling's to a low NDF (23.80%) complete feed resulted in similar milk yield; Yang and Beauchemin (2006a) who reported that cows fed on barley silage based complete rations with 32 to 33 per cent NDF and varying peNDF had a similar milk yield and Neto *et al*. (2014) who found that the milk yield of cows fed on low peNDF corn silage and high peNDF sugarcane silage, based complete diets, were similar.

The DMI per kg of milk produced by the cows fed on the three experimental rations: T1, T2 and T3 in phases I, II and the total experiment were, 1.04, 1.02, 1.06 kg; 1.48, 1.43, 1.41 kg and 1.26, 1.23, 1.24 kg, respectively, with the intakes in the three dietary treatments being similar (P>0.05). These values are comparable to those observed in studies conducted in lactating dairy cows by Yang and Beauchemin (2006a) using corn silage based complete rations of varying peNDF, where the values ranged from 1.28 to 1.37 kg and Yang and Beauchemin (2006b) using barley silage based complete rations with varying peNDF, the values ranged from 1.35 to 1.40 kg and Raseel *et al*. (2018) who reported values of 1.28 and 1.18 kg in cows fed on complete rations T1 and T2, respectively, where T1 consisted of maize alone and T2 comprised of one third of the maize being replaced by pineapple waste. The values obtained in the present study in both the phases as well as the total experiment in all the three dietary treatments were better than those

DOI 10.5455/ijlr.20190116080018

obtained by Pachauri and Mahanta (1997) who reported that the DMI per kg of milk produced in lactating cows fed on complete feeds in mash and pellet form were 1.70 and 1.81 kg, respectively.

Table 4: DMI, milk yield and cost per kg milk production of animals maintained on three experimental rations in phase II

Parameter	T1	T2	T3	F-value (p-value)
Total DMI, kg	1524.62 ± 32.47	1530.67 ± 59.78	1556.76 ± 29.96	0.158^{ns} (0.855)
Daily DMI, kg	15.56±0.33	15.62±0.61	15.89±0.31	0.576^{ns} (0.573)
Total milk produced, kg	1039.47 ± 38.45	1084.67 ± 66.56	1138.97 ± 77.02	0.629^{ns} (0.547)
Daily milk yield, kg	10.61±0.39	11.07±0.68	11.62±0.79	0.862^{ns} (0.441)
DMI per kg milk produced, kg	1.48 ± 0.06	1.43 ± 0.06	1.41 ± 0.12	0.166^{ns} (0.848)
Total feed intake, kg	1724.09 ± 36.72	1740.99 ± 67.99	1775.1 ± 34.16	0.284^{ns} (0.757)
Cost per kg of feed, Rs.	21	21	21	-
Total cost of feed, Rs.	36205.95 ± 771.03	36560.69 ± 1427.8	37277.03 ± 717.45	0.284^{ns} (0.757)
Cost per kg milk produced, Rs.	35.08 ± 1.50	34.05 ± 1.48	33.72 ± 2.95	0.114^{ns} 0.893

Table 5: DMI, milk yield and cost per kg milk production of animals maintained on three experimental rations in the total experimental period

Parameter	T1	T2	T3	F-value (p-value)
Total dry matter intake, kg	2535.28 ± 68.08	2613.02 ± 105.74	2665.12 ± 55.17	0·679^{ns} (0.522)
Daily DMI, kg	13.76±0.37	14.36±0.58	14.64±0.30	1.137^{ns} (0.345)
Total milk produced, kg	2016.32 ± 70.88	2149.32 ± 126.23	2199.8 ± 128.15	0.721^{ns} (0.502)
Daily milk yield, kg	10.94±0.38	11.87±0.69	12.12±0.70	1.164^{ns} (0.337)
Dry matter intake per kg milk produced, kg	1.26 ± 0.05	1.23 ± 0.05	1.24 ± 0.09	0.082^{ns} (0.921)
Total feed intake, kg	2882.44 ± 77.53	2995.15 ± 121.28	3066.89 ± 63.63	1.047^{ns} (0.375)
Total cost of feed, Rs.	64006.33 ± 1750.86	66660.66 ± 2711.86	68280.11 ± 1438.58	1.118^{ns} (0.353)
Cost per kg of milk produced, Rs.	31.89 ± 1.16	31.27 ± 1.23	31.73 ± 2.41	0.036^{ns} (0.965)

The data given in Table 3 and 4 showed that the cost per kg of feed was Rs.24/- and Rs.21/- in phases I and II, respectively. The formula cost per kg of the three experimental rations, T1, T2 and T3, in phase I and II (Tables 6 and 7) was Rs.15.24, 15.75, 16.10 and Rs.14.84, 14.40 and 14.07/- respectively. This indicated that of the total feed cost, 36.50, 34.38, 32.92 and 29.33, 31.42, 33.00 per cent in phases I and II, respectively, were on account of overheads. These high overheads occurred, because feed formulation and production were carried out on a small scale, exclusively for research purpose. The data on cost per kg milk produced in phases I, II and the total experiment given in Tables 3, 4 and 5, respectively, reveal that the values in cows fed on the three experimental rations, T1, T2 and T3 were Rs.28.58, 28.50, 29.70; 35.08, 34.05, 33.72 and 31.89, 31.27 and 31.73, respectively, with the values in the three dietary treatments being similar (P>0.05). The values in phase I are lower than those of Raseel *et al*. (2018) who reported that the cost per kg milk produced by early lactating dairy cows fed on complete rations T1 and T2, where T1

DOI 10.5455/ijlr.20190116080018

consisted of maize alone and T2 comprised of one third of the maize being replaced by pineapple waste were Rs. 36.82 and 34.22, respectively.

Table 6: Formula cost of experimental complete rations fed to cows in phase I

Ingredients	Cost/ kg	Early Lactation					
		T1		T2		T3	
		Inclusion (kg)	Cost (Rs.)	Inclusion (kg)	Cost (Rs.)	Inclusion (kg)	Cost (Rs.)
Maize	16.3	37	6.031	27	4.401	16	2.608
Coconut cake (de-oiled)	20.9	11	2.299	12	2.508	17	3.553
Rape seed meal	18.7	11	2.057	12	2.244	11	2.057
De-oiled rice bran	14.7	20	2.94	19	2.793	16.5	2.4255
Paddy straw	8.5	14	1.19	21	1.785	29	2.465
Molasses	8	5	0.4	5	0.4	5	0.4
Calcite	9	1.5	0.135	1.5	0.135	1.5	0.135
Salt	5	0.5	0.025	0.5	0.025	0.5	0.025
Vegetable fat	65	0	0	2	1.3	3.5	2.275
Total		100	15.08	100	15.59	100	15.93
Vitamin AD_3E supplement	880	0.1	0.88	0.1	0.88	0.1	0.88
Keramin Forte	65	0.05	0.0325	0.05	0.0325	0.05	0.0325
Curatox	80	0.05	0.04	0.05	0.04	0.05	0.04
Grand total			**15.24**		**15.75**		**16.1**

Table 7: Formula cost of experimental complete rations fed to cows in phase II

Ingredients	Cost/ kg	Mid Lactation					
		T1		T2		T3	
		Inclusion (kg)	Cost (Rs.)	Inclusion (kg)	Cost (Rs.)	Inclusion (kg)	Cost (Rs.)
Maize	16.3	38	6.194	30	4.89	21	3.423
Coconut cake (de-oiled)	20.9	5	1.045	8	1.672	12	2.508
Rape seed meal	18.7	10	1.87	10	1.87	10	1.87
De-oiled rice bran	14.7	26	3.822	23	3.381	21	3.087
Paddy straw	8.5	14	1.19	22	1.87	29	2.465
Molasses	8	5	0.4	5	0.4	5	0.4
Calcite	9	1.5	0.135	1.5	0.135	1.5	0.135
Salt	5	0.5	0.025	0.5	0.025	0.5	0.025
Vegetable fat	65	0	0	0	0	0	0
Total		100	14.68	100	14.24	100	13.84
Vitamin AD_3E supplement	880	0.1	0.88	0.1	0.88	0.1	0.88
Keramin Forte	65	0.05	0.0325	0.05	0.0325	0.05	0.0325
Curatox	80	0.05	0.04	0.05	0.04	0.05	0.04
Grand total			**14.84**		**14.4**		**14.07**

The values of cost per kilogram of milk produced, observed in the present study are higher than those of Khan *et al*. (2010) who reported values ranging from Rs.4.84 to 6.63 in lactating dairy cows fed on wheat straw based complete feeds in mash, pellet and block form, Kumar *et al*. (2010) who reported values ranging

DOI 10.5455/ijlr.20190116080018

from Rs.8.65 to 9.89 in Murrah buffaloes fed on complete diets and Lailer *et al*. (2010) who reported values ranging from Rs.12.14 to 14.00 in dairy cows fed on complete feed blocks made from various cereal straws. The high feed cost observed in the present study carried out in 2015, in comparison to those of the above three workers may be due to the fact that all those works were carried out five years back, when the ingredient costs were much less and since all those studies were conducted in the North and Western parts of India where concentrate as well as roughage ingredients, especially paddy straw were much cheaper than Kerala.

Conclusion

From the overall evaluation of different rations in both the phases as well as the total experimental period, it could be observed that the animals in all the three dietary treatments performed well, suggesting that complete rations with 25 to 35 per cent NDF, containing paddy straw as the sole source of roughage, with the rest of the NDF being met from NFFS, can be recommended for use among early and mid-lactation dairy cows. It is always advisable to go in for bulk production, so that the cost of production of complete feed can be minimised. Paddy straw, the roughage component can be procured in bulk from the paddy cultivating tracts at the time of harvest, stored in bulk silos, which can then be chopped and incorporated into complete feeds.

Acknowledgements

The authors express their gratitude to the Kerala Veterinary and Animal Sciences University, Pookode, Wayanad for providing the necessary fund and facilities required for the study.

References

1. AOAC. (2016). Official Methods of Analysis (20th Ed.). *Association of Official Analytical Chemists*, Washington, D. C. pp. 1-77.
2. Datta, D. (2013). Indian Fodder Management towards 2030: A Case of Vision or Myopia. *Int. J. Manag. Soc. Sci. Res.*, 2(2): 33-41.
3. Depies, K. K. and Armentano, L. E. (1995). Partial replacement of alfalfa fibre with fibre from ground corn cobs or wheat middlings. *J. Dairy Sci.*, 78(6): 1328-1335.
4. Duncan, D. B. (1955). Multiple range and F-test. *Biometrics.* 11: 1-42.
5. Garg, M. R. (1997). Nutritional constraints and strategies for sustainable milk production. In: *Proceedings of VIII Animal Nutrition Research Workers Conference;* 12th to 14th December, 1997, Chennai. Tamil Nadu Veterinary and Animal Sciences University. pp. 15-24.
6. Government of Kerala. (2013). *Agricultural Development Policy of Kerala State.* Department of Agriculture, Government of Kerala. 349p.
7. ICAR-NIANP. (2013). *Nutrient Requirements of Animals – cattle and buffalo.* (3rd Ed.). Indian Council of Agricultural Research, New Delhi. p.24.
8. Kendall, C., Leonardi, C., Hoffman, P.C. and Combs, D. K. (2009). Intake and milk production of cows fed diets that differed in dietary neutral detergent fibre and neutral detergent fibre digestibility. *J. Dairy Sci.*, 92(1): 313–323.

DOI 10.5455/ijlr.20190116080018

9. Khan, S.R., Singh, S.K. and Mudgal, V. (2010). Effect of feeding complete rations on the performance of lactating crossbred cows. *Indian J. Anim. Nutr*., 27(3); 261-264.
10. Kumar, M. K., Sudhakar, K., Nagalakshmi, D. and Mahender, M. (2010). Performance of lactating Murrah buffaloes on sheanut cake (*Vitellaria paradoxa*) based complete diets. *Indian J. Anim. Nutr.*, 27(4): 389-395.
11. Lailer, P.C., Dahiya, S. S. and Chauhan, T. R. (2005). Complete feed for livestock - concept, present status and future trend: A review. *Indian. J. Anim. Sci.*, 75(1): 84-91.
12. Lailer, P.C., Daiya, S.S., Lal, D. and Chauhan, T.R. (2010). Effect of complete feed blocks on the performance of lactating buffaloes. *Indian J. Anim. Nutr.*, 27(2): 147-151.
13. Neto, A. S., Bispo, A. W., Junges, D., Bercht, A. K., Zopollatto, M., Daniel, J. L. P. and Nussio, L. G. (2014). Exchanging physically effective neutral detergent fibre does not affect chewing activity and performance of late-lactation dairy cows fed corn and sugarcane silages. *J. Dairy Sci.*, 97(11): 7012–7020.
14. NRC (2001). Nutrient requirements for dairy cattle. (7th Ed). *National Acad. Sci*., Washington, D.C. USA. p. 408.
15. Owen, J.B. (1984). Complete diet feeding for cattle. *Livestock. Prod. Sci.*, 11(3): 269-285.
16. Pachauri, V.C. and Mahanta, S.K. (1997). Forage production and processing for efficient utilization. In: *Proceedings of VIII Animal Nutrition Research Workers Conference;* 12th to 14th December, 1997, Chennai. Tamil Nadu Veterinary and Animal Sciences University. pp. 82-90.
17. Radha Devi, D. and Ajith Kumar, N. (2011). Population pressure on land in Kerala. *Working paper No. 24.* Centre for Socio – Economic and Environmental Studies, Kochi, Kerala. 28p.
18. Raseel, K., Chacko, B. and Sunanda, C. (2018). Evaluation of energy rich unconventional feed based complete feed on production performance of cross bred dairy cows in early lactation. *Proc. 10th Kerala Vet. Sci. Cong.*, 337-341.
19. Reyya, K. R., Dhulipalla, S. K. and Dhulipalla, N. K. (2014). Nutrient utilisation in buffalo bulls fed crop residue based complete rations supplemented with or without yeast culture. *J. Adv. Vet. Res.*, 4(1): 28-33.
20. Sadagopan, V. R. and Sunder, G. S. (1997). Quality control of feed ingredients and compounded feed for sustainable milk and egg production. In: *Proceedings of VIII Animal Nutrition Research Workers Conference;* 12th to 14th December, 1997, Chennai. Tamil Nadu Veterinary and Animal Sciences University. pp. 30-37.
21. Snedecor, G.W. and Cochran, W.G. (1994). *Statistical Methods*. (8th Ed.). The Iowa State University Press, Ames, IA. 314p.
22. Stone, W. C. (2004). Nutritional approaches to minimize subacute ruminal acidosis and laminitis in dairy cattle. *J. Dairy Sci*., 87(E. Suppl.): 13–26.
23. Van Soest, P. J., Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *J. Dairy Sci.*, 74: 3583–3597.
24. Weiss, W. P. and Wyatt, D. J. (2002). Effects of feeding diets based on silage from corn hybrids that differed in concentration and *in vitro* digestibility of neutral detergent fibre to dairy cows. *J. Dairy Sci.*, 85(12): 3462–3469.
25. Yang, W.Z. and Beauchemin, K. A. (2005). Effects of physically effective fibre on digestion and milk production by dairy cows fed diets based on corn silage. *J. Dairy Sci*., 88(3): 1090-1098.
26. Yang, W.Z. and Beauchemin, K. A. (2006a). Increasing the physically effective fibre content of dairy cow diets may lower efficiency of feed use. *J. Dairy Sci.*, 89(7): 2694-2704.
27. Yang, W.Z. and Beauchemin, K. A. (2006b). Physically effective fibre: Method of determination and effects on chewing, ruminal acidosis, and digestion by dairy cows. *J. Dairy Sci.*, 89(7): 2618–2633.

DOI 10.5455/ijlr.20190116080018