

Evaluation of the Performance of Lactating Dairy Cows Fed on Paddy Straw Plus Non-Forage Fibre Sources Based Complete Feeds with Varying Levels of Neutral Detergent Fibre

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Abstract

A study of six months duration was conducted to evaluate the performance of lactating dairy cows fed on paddy straw plus non-forage fibre sources such as coconut cake and deoiled rice bran, based complete feeds with varying levels of neutral detergent fibre (NDF) on the basis of milk urea nitrogen (MUN), rumen ammonia and nitrogen (N) balance, in two phases of three months (90 days) duration each; viz., early and mid-lactation, 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 18 lactating dairy cows, divided into three groups of six each. The daily milk yield was recorded; the fortnightly milk urea nitrogen, the nitrogen balance at the end of each phases and the rumen ammonia at the end of the total experiment, were estimated. The average daily dry matter intake of cows fed on the three experimental rations were similar ($P < 0.05$), from the third fortnight onwards till the end of the experiment, even though the DMI tended to be higher in T3 and T2 as compared to T1. The milk yield of cows in all the dietary treatments were similar ($P > 0.05$) throughout the experiment, even though it tended to increase with increase in NDF content of the ration. The milk urea nitrogen (MUN) content of cows decreased linearly and significantly ($P < 0.05$), with increase in the NDF content. The N balance of cows fed on the experimental rations, T1, T2 and T3 in phases I and II were similar ($P > 0.05$). The rumen ammonia production was significantly lower ($P < 0.05$) in T3 than T1 and T2, with T1 and T2 being similar ($P > 0.05$). These results reveal that cows in all the three dietary treatments performed well, with the complete rations T3 and T2, showing better performance than T1, suggesting that paddy straw plus non-forage sources based complete rations, having a total NDF of 25 to 35 per cent NDF can be recommended for use among early and mid-lactation dairy cows, with 35 per cent being the ideal NDF level, followed by 30 per cent.

Keywords: Complete Feeds, MUN, N Balance, NDF, Non-Forage Fibre Sources, Paddy Straw and Rumen Ammonia

Introduction

The fibrous and non-fibrous carbohydrate fractions of the diet are the major sources which contribute to the energy requirements of lactating dairy cows. To achieve maximum production, dairy rations should contain adequate NDF, i.e., the useful fibre, at the same time not compromising on the non-fibrous carbohydrate fractions so that optimum energy intake and rumen health are ensured. The National Research Council (NRC) of 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 (DAHD, 2017) and in Kerala, the deficit was 78.02 per cent (NDDDB, 2016).

In this regard, incorporation of fibre from non-forage sources such as brans like rice bran and oil cakes like coconut cake have to be thought of. NDF from such non-forage sources have got lesser rumen filling effect, are less lignified than NDF from forages, have got lower rumen filling effect, increase the dry matter intake and also the milk yield (Reyya *et al.*, 2014). The need of the time was to blend crop residues such as straws along with locally available agro-industrial by products like brans and oil cakes like coconut cake, which are non-forage fibre sources (NFFS) and also good sources of NDF. Once the NDF requirement is met in this manner, other concentrate ingredients can be added to it 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 and rest of the NDF supplied through non forage fibre sources (NFFS), may be a viable feeding practice. At the same time, it should be ensured that such a diet never causes any harmful effect, to the health of cows. Geerts *et al.* (2004) observed that protein and carbohydrates are degraded continuously and almost simultaneously in the rumen and hence a balanced as well as synchronous supply of degradable protein and energy should be ensured in the rumen, failing which the proteins will be degraded to first to ammonia, which will subsequently be converted to urea and excreted through the urine and milk.

Urea N levels in blood plasma and milk of a cow are highly related. Therefore, MUN values are representative of urea levels of blood and other body fluids (Qiu *et al.*, 2003) and can be used as a marker to monitor protein status of cows (Leonardi *et al.*, 2005). In addition, it will also be an indicator as to whether there was a synchronous supply of soluble carbohydrates to the rumen microbes, for synthesis of microbial protein, because extra energy is required to excrete the excess urea mainly through the urine and also through the dung and milk. Extra energy expenditure in this manner reduces the energy availability for milk production and can result in reduced milk yield (Chizzotti *et al.*, 2007). Since, the main route of elimination of excess urea is through the urine, assessment of the nitrogen balance is a valuable tool for determining the appropriateness of the protein content in the cow's diet, with respect to its availability for the animal (Silva *et al.*, 2014). At the same time, if the rumen does not maintain a minimum level of ammonia, milk yield may drop because of reduced microbial protein synthesis (Grummer *et al.*, 1984). However, excess concentrations of ammonia in the rumen can also have detrimental effects on milk production as the efficiency of utilisation of protein (Agle *et al.*, 2010) and energy (Reed *et al.*, 2017) for milk production sharply decreases.

Therefore, a combined assessment of all the three above mentioned parameters, viz., MUN, N balance and rumen ammonia will serve as a valuable tool for assessment of the appropriateness and availability of protein and soluble carbohydrate in the cow's diet, with respect to milk production. Hence, productive evaluation of the performance of lactating dairy cows, would be more ideal, if all the above three parameters are assessed along with milk production. The optimum level of NDF required for obtaining a positive N balance, with satisfactory levels of MUN and rumen ammonia, in dairy cows of various stages of lactation, also needs to be studied. Therefore, this investigation was carried out to evaluate the performance of lactating dairy cows fed on paddy straw plus non-forage fibre sources based complete feeds with varying levels of NDF, on the basis of MUN, N balance and rumen ammonia.

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 with uniform 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, being fed with complete rations containing varying/

graded 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 1 and 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 AD₃E supplement (containing 10,000 I.U of Vitamin A, 2000 I.U of Vitamin D₃ 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

Table 2: Chemical composition of complete 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
ME* (MJ/ kg DM)	9	8.87	8.41	9.04	8.54	8.24

* Calculated value

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; the balance feed was collected manually and weighed, twice every day. Samples of left-over portions of the feed were taken daily for analysing the moisture content and the daily dry matter intake was calculated. Milk yield was recorded daily and the fortnightly pooled milk samples were analysed for MUN (Bector *et al.*, 1998). A metabolism trial of five days duration was conducted during the last week, in both phase I and phase II of the feeding trial, to collect the dung, urine and milk samples from all the animals, to estimate their N content as per the standard procedures described in AOAC (2016) and the N balance was determined. Rumen liquor was collected from all the animals at the end of the total experiment and subjected to further analysis, for estimation of rumen ammonia nitrogen (Beecher and Whitten, 1970). Data gathered on the various parameters, in the two phases were analysed statistically by statistical software SPSS version 21.0 (2012).

Results and Discussion

The data on average daily dry matter intake (DMI) of cows maintained on the three experimental rations in phases I and II are given in Table 3.

Table 3: Average daily DMI of cows fed on the three experimental rations in phases I and II, kg

Phase	Fortnight	DMI/ animal/ day		
		T1	T2	T3
I	1	10.29 ^a ±0.49	12.62 ^{ab} ±0.99	13.88 ^b ±0.86
	2	10.60 ^a ±0.42	12.11 ^{ab} ±0.60	13.10 ^b ±0.32
	3	11.77±0.54	12.45±0.63	12.52±0.38
	4	12.85±0.59	12.53±0.55	12.52±0.44
	5	12.89±0.38	12.91±0.65	12.88±0.48
	6 (Final)	13.80± 0.71	14.70± 0.66	14.27±0.56
	Mean±SE	12.03±0.43	12.89±0.58	13.19±0.38
II	1	14.89±0.61	15.05±0.64	14.95±0.44
	2	15.50±0.59	15.23±0.62	15.73±0.54
	3	16.12±0.57	15.88±0.71	16.15±0.32
	4	16.50±0.54	16.38±0.85	16.15±0.36
	5	16.19±0.43	16.51±0.67	16.40±0.39
	6	15.28±0.48	15.42±0.53	16.21±0.29
	7 (Final)	14.41±0.31	14.87±0.49	15.62±0.38
	Mean ± SE	15.56±0.33	15.62±0.61	15.89±0.31

*Average of six values; a,b: means with different superscripts in the same row differ significantly ($P < 0.05$)

The data presented in Table 3 indicate that during the first two fortnights of phase I, the DMI increased linearly with increase in NDF content of the ration with the cows fed on ration T3 having the highest DMI followed by those fed on T2 and T1 in descending order, with the DMI of the animals in T3 being significantly higher ($P < 0.05$) than that of T1 and T2 being comparable to both T1 and T3. This result is in agreement with the previous work of Ruiz *et al.* (1995) and Broderick *et al.* (2003) who reported that the DMI of cows, increased linearly with increase in NDF content of complete diets. From the third fortnight onwards, the DMI of cows fed on the three experimental rations were similar ($P > 0.05$), throughout phase I.

Table 4: Average daily milk yield* of cows maintained on three experimental rations, kg

Phase	Fortnight	Milk yield/ animal/ day (kg)		
		T1	T2	T3
I	Initial	10.17±0.57	10.17±0.50	10.22±0.68
	1	11.63±0.60	12.06±0.98	12.58±1.18
	2	11.94±0.70	12.95±0.82	13.04±0.80
	3	11.95±0.51	13.14±0.73	13.03±0.64
	4	11.92±0.48	12.68±0.75	12.70±0.58
	5	11.40±0.41	12.55±0.67	12.14±0.51
	6 (Final)	10.94±0.65	12.66±0.63	12.28±0.72
	Mean±SE	11.63±0.51	12.67±0.74	12.63±0.64
II	Initial	10.94±0.65	12.66±0.63	12.28±0.72
	1	11.53±0.44	13.39±0.81	12.75±0.75
	2	11.62±0.38	12.44±0.85	12.59±0.78
	3	10.98±0.52	11.04±0.80	11.99±0.84
	4	10.55±0.41	10.84±0.69	11.82±0.91
	5	10.43±0.46	10.71±0.68	11.08±0.83
	6	9.85±0.53	9.79±0.60	10.75±0.79
	7 (Final)	9.30±0.42	9.28±0.50	10.38±0.77
Mean ± SE	10.61±0.39	11.07±0.68	11.62±0.79	

Similarity in DMI between cows fed on different experimental rations, as found in this experiment, from the third to the sixth fortnight, was also obtained by Weiss and Wyatt (2002) and Kendall *et al.* (2009) in lactating cows fed on complete diets with varying levels of NDF and varying digestibility of NDF of the forage used. Similarity in DMI, between treatments, as observed in phase II of the present study was also observed by Depies and Armentano (1995) who reported that addition of NFFS such as ground maize cobs and wheat middlings to a low NDF (23.80%) complete feed and Pereira and Armentano (2000) who reported that replacement of forage NDF with NFFS, did not affect the DMI of mid lactation cows. The data on average daily milk yield of cows maintained on the three experimental rations in phases I, II and the total experiment of the experiment are given in Table 4. The above data reveal that the milk yield of cows in all the dietary treatments were similar ($P>0.05$), with the values being 11.63, 12.67, 12.63kg and 10.61, 11.07, 11.62kg, respectively, for cows fed on the experimental rations T1, T2 and T3, in phases I and II, respectively. Similarity in milk yield among the different dietary treatments, as observed in this study were also reported by Hundal *et al.* (2004) who reported that the milk yield of cross bred milking cows fed on a TMR (15.43 kg) and a conventional hay-concentrate feed (15.02 kg) were similar; Girdhar and Balaraman (2005) who observed that the milk yield of lactating cross bred cows fed on berseem based TMRs containing varying levels of protein and energy, viz., 12 per cent CP, 60 per cent TDN and 14 per cent CP, 65 per cent TDN, were similar, the values being 11.46 and 11.08 kg, respectively.

The findings of Khan *et al.* (2010), who reported statistically similar milk yield values of 7.78, 7.97 and 8.77 kg in crossbred milking cows fed on a conventional straw-concentrate ration, wheat straw based complete feed in mash and pellet form, respectively; Aguerre *et al.* (2016) who observed that the milk yield of lactating Holstein cows fed on TMRs with a constant forage: concentrate ratio of 55:45 and NDF content of 28.70 per cent NDF, but varying in NDF digestibility, were similar, with the values being in the range of 32.10 ± 2.20 kg per day; Santana *et al.* (2016) who found that the milk yield of lactating Jersey cows fed on TMRs having soyabean and okara meal as protein sources with NDF content of 35.30 and 36.30 per cent, respectively were similar (mean = 20.70 kg/ day) and Raseel *et al.* (2018) who reported that the milk yield of dairy cows fed on a conventional complete ration and a complete ration in which 1/3rd of the energy source maize in the complete ration was replaced with an energy rich unconventional feed, pineapple waste, were similar, the values being 11.94 and 12.94 kg, respectively, are in agreement with the results of the present investigation. The findings of Ren *et al.* (2015) who reported that the milk yield of lactating dairy cows fed on a grass based TMR with high NDF (42.80 per cent) and low CP (14.10 per cent) was significantly lower than those fed on a TMR with low NDF (28.50 per cent) and high CP (17.80 per cent) are however, contradictory to the results of the present study.

Table 5: Average MUN content of milk* from cows maintained on the three experimental rations, mg %

Phase	T1	T2	T3
I	12.50±0.06 ^a	10.40±0.10 ^b	9.35±0.07 ^c
II	13.14±0.08 ^a	11.12±0.11 ^b	10.10±0.10 ^c

*Average of six values; a,b: means with different superscripts within a column differ significantly ($P<0.05$)

The data on average MUN content of milk of cows fed on the three experimental rations, T1, T2 and T3, in phases I and II given in Table 5 indicate that the values were in the normal range of domestic cattle and within the maximum of 14 mg per cent, as described by Ayasan *et al.* (2011). The above data reveal that the MUN content of cows fed on ration T3 was significantly lower ($P<0.05$) than those fed on T2 and T1, with T2 being significantly lower ($P<0.05$) than T1, in both the phases. A thorough scrutiny of the MUN data depicted in the Table, reveal that the MUN values in Phase I of the present study are comparable to those reported by Broderick (2003) where the values ranged from 9.20 to 15.90 mg per cent, Macmillan *et al.* (2017) whose values were in the range of 12.20 to 12.30 mg per cent and Raseel *et al.* (2018) where the values ranged from 11.59 to 12.60 mg per cent, all of them in early lactation dairy cows, fed on complete rations. The MUN values in phase I of the present study are lower than those reported by Filho *et al.* (2000) whose values ranged from 20.60 to 25.00 mg per cent and Johansson *et al.* (2015) who reported values in the range of 13.56 to 13.56 per cent, both of them in dairy cows of early lactation fed on complete rations. The MUN values in phase II of the present study are comparable to those of Johansson *et al.* (2015) who reported values ranging from 12.66 to 12.77 mg per cent in mid lactation dairy cows fed on cold pressed or full fat rape seed based total mixed rations. The phase II, the MUN values reported were lower than those of Delahoy *et al.* (2003) who obtained values ranging from 14.80 to 16.30 mg per cent in mid lactation dairy cows fed on complete feeds, containing NFFS such as cracked and steam flaked corn.

The findings of Geerts *et al.* (2004) who observed that the MUN values of cows fed on high NDF, maize silage based complete diets were significantly lower than those fed on low NDF grass silage based complete diets and Kelzer *et al.* (2009) who reported that the MUN content of Holstein cows fed on a high NDF and unsupplemented complete diet was significantly lower than those fed on a low NDF complete diet containing 15 per cent dried distillers grains plus solubles, are also in accordance with the findings of the present investigation. The observations of Raseel *et al.* (2018) who found that the MUN content of early lactation dairy cows fed on a conventional complete ration and a complete ration in which 1/3rd of the energy source maize in the conventional ration was replaced with pineapple waste, are contradictory to the results of the present study, *vis – a - vis*, phase I. The significantly lower ($P < 0.05$) value of MUN reported in cows fed on the experimental ration T3 in comparison to those fed on T2 and T1; with T2 being significantly lower ($P < 0.05$) than T1, i.e., MUN values decreasing with increase in NDF content of the ration might be due to the fact that at higher levels of NDF in the ration, synchronous supply of energy and protein to the rumen microbes must have been ensured, in comparison to lower levels of NDF, which is in agreement with the observation of Geerts *et al.* (2004). Moreover, at higher levels of NDF in the ration, the energy expenditure to excrete the excess urea might also have been less (Chizzotti *et al.*, 2007), with resultant increase in efficiency of utilisation of energy for milk production (Reed *et al.*, 2017) and hence the linear and higher, though non-significant ($P > 0.05$), increase in milk production, with increase in NDF content of the ration, as depicted in Table 4.

The data presented in Table 6 reveal that the N balance and per cent retention of N of cows in the dietary treatments T1, T2 and T3 in phase I were 14.94, 36.53, 37.82 g per day and 6.12, 11.83, 12.76 per cent respectively, with no significant difference ($P > 0.05$) between the treatments. Nitrogen balance values comparable to those obtained in phase I of the present study were obtained by Hozhabri and Singhal (2009) who reported N balance values in the range of 18.79 to 22.62 g per day and per cent retention of N values ranging from 16.16 to 18.85 in cross bred heifers fed on wheat straw based complete feed blocks having varying levels of protected protein.

Table 6: Nitrogen balance* of cows maintained on the three experimental rations in phases I and II

Phase	Treatment	N intake (g/ day)	N outgo (g/ day)				N balance (g/ day)	% retention of N
			Dung	Urine	Milk	Total		
I	T1	251.32± 8.00 ^a	131.31± 4.73	56.78± 6.19	48.28± 2.84	236.38± 11.47	14.94±5.11	6.12±2.08
	T2	301.60± 16.28 ^b	155.75± 10.35	49.60± 9.30	59.72± 5.46	265.08± 13.49	36.53±8.40	11.83±2.62
	T3	290.91±9.60 ^b	149.54± 6.17	44.89± 3.60	58.66± 5.41	253.09± 7.74	37.82±8.62	12.76±2.73
Phase	Treatment	N intake (g/ day)	N outgo (g/ day)				N balance (g/ day)	% retention of N
			Dung	Urine	Milk	Total		
II	T1	274.82±8.11 ^a	131.06± 3.00	49.70± 3.42	43.98± 2.76	224.74± 5.80	50.08±5.74	18.09±1.77
	T2	315.33±9.65 ^b	143.45± 12.72	46.75± 4.03	45.18± 3.39	235.38± 15.10	79.94±8.94	25.61±3.14
	T3	305.07±4.92 ^b	131.29± 9.50	46.01± 3.42	48.89± 4.13	226.19± 10.79	78.88±12.42	25.72±3.84

*Average of six values; a,b: means with different superscripts in the same column differ significantly ($P < 0.05$)

The N balance and per cent retention of N of cows in the dietary treatments T1, T2 and T3 in phase II were 50.08, 79.94, 78.88 g per day and 18.09, 25.61, 25.72 per cent, respectively, with the values being similar ($P > 0.05$). The N balance as well as the per cent retention of N observed in phase II of the present study are comparable to those of Girdhar and Balaraman (2005) who reported N balance values ranging from 44.15 to 104.80 g per day and per cent retention of N values ranging from 10.94 to 22.90 in lactating cross bred cows fed on berseem based TMRs. Examination of the data on N balance given in Table 6, indicated that cows fed on ration T1 had significantly lower ($P < 0.05$) N intake. Perusal of the data given in Table 3, revealed that the average daily DMI of cows fed on the three experimental rations during the first two fortnights of phase I, increased linearly and significantly ($P < 0.05$), with increase in NDF content of the ration with the cows fed on ration T3, having the highest DMI followed by those fed on T2 and T1 in descending order. Even though the DMI was similar ($P > 0.05$), from the third fortnight onwards till the end of the experiment, it tended to be higher in T3 and T2 as compared to T1. A scrutiny of the N outgo data given in Table 6 indicate that cows in group T1, which had a lower intake, excreted more N with respect to their intake, which resulted with the result that a lower, but non-significant ($P > 0.05$), N balance as well as per cent

retention of N was observed in cows of T1, than those fed on the rations, T2 and T3. A thorough evaluation of the results obtained in the present study in phases I and II, showed that the positive N balance observed in cows fed on all the three experimental rations, indicated retention of protein, which in turn provided conditions that prevented performance loss, thereby ensuring that the requirements of protein in the diets were met.

The average values for rumen ammonia were 26.02 ± 0.27 , 25.21 ± 0.22 and 22.83 ± 0.49 mg per 100 ml in cows fed on the experimental rations T1, T2 and T3, respectively, with the rumen ammonia values of cows fed on ration T3 being significantly lower ($P < 0.05$) than those fed on rations T1 and T2, with T1 and T2 being similar ($P > 0.05$). The rumen ammonia values of the present study are comparable to those of Samantha *et al.* (2006) who reported that the rumen ammonia levels of crossbred cattle fed on a dried grass based complete feed in mash form as well as well as a conventional grass-concentrate ration were similar, the values being 22.15 and 23.41 mg per cent, respectively and Raseel *et al.* (2018) who observed that the rumen ammonia content of early lactation dairy cows fed on a conventional complete ration and a complete ration in which 1/3rd of the energy source maize in the complete ration was replaced with pineapple waste were similar, with the values being 25.87 and 25.45 mg per 100 ml, respectively. Significant difference of rumen ammonia values, between treatments, such as those found in the present study were observed by Yang and Beauchemin (2006) who reported that the rumen ammonia content significantly increased with decrease in peNDF content of the diet in mid lactation cows fed on corn silage based complete diets. Similarity in rumen ammonia values between treatments, which are contradictory to the results of the present study were observed by Samantha *et al.* (2006) and Raseel *et al.* (2018), as described earlier.

Table 7: Rumen ammonia* levels of cows maintained on the three experimental rations at the end of experiment

Treatment	Rumen ammonia (mg/100ml)
T1	26.02 ± 0.27^a
T2	25.21 ± 0.22^a
T3	22.83 ± 0.49^b

*Average of six values; a,b: means with different superscripts in the same column differ significantly ($P < 0.05$)

Examination of the data on rumen ammonia given in Table 7 along with the data on milk yield given in Table 4, MUN given in Table 5 and N balance given in Table 6 reveal that the efficiency of utilisation of energy for milk production was the highest in ration T3, followed by T2 and T1, in descending order, which is in agreement with the findings of Reed *et al.* (2017). The probable reason could be that, as opined by Geerts *et al.* (2004), if protein and carbohydrates are degraded continuously and simultaneously in the rumen, a balanced supply of protein and energy will be ensured in the rumen and such a situation was ensured in the diets T2 and T3. On the other hand, diet T1 with the highest soluble carbohydrate content, might have underwent rapid fermentation, as a result of which greater energy was quickly available in the rumen for the activity of proteolytic organisms in the rumen, which degraded the dietary protein rapidly and hence rumen ammonia level got elevated, which was utilised by the microbes for microbial protein synthesis. However, once the rumen ammonia exceeded the threshold, it had to be transported to liver, for which greater energy might have been expended (Chizzotti *et al.*, 2007). Therefore, it resulted in less efficient utilisation of energy for milk production (Reed *et al.*, 2017), which subsequently manifested as lower, but non-significant ($P > 0.05$) milk yield in T1, as compared to T2 and T3.

Conclusion

An overall critical evaluation of the results obtained in the both the phases of the experiment, reveal that cows in all the three dietary treatments performed well, with the complete rations T3 with 35 per cent NDF and T2 with 30 per cent NDF, showing better performance than T1 with 25 per cent NDF, as evinced by a lower MUN ($P < 0.05$), lower rumen ammonia and greater N balance, in T2 and T3, than T1. Among T2 and T3, T3 was the better ration, as evinced by a significantly lower ($P < 0.05$) MUN and rumen ammonia in T3 than T2. Therefore, it can be concluded 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, with 35 per cent being the ideal NDF level, followed by 30 per cent..

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Conflict of Interests

There is no conflict of interest.

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