EVALUATION OF COMPLETE RATIONS CONTAINING UNCONVENTIONAL FEEDS IN EARLY LACTATING DAIRY COWS

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(16-MVP-012)

THESIS

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DECLARATION

I hereby declare that this thesis, entitled **"Evaluation of complete rations containing unconventional feeds in early lactating cows"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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RASANATH K

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1. INTRODUCTION

India, though an agricultural country, with a human population of 132 crores, second only to China with 139.27 crores, is having one of the fastest growing economies of the world, providing livelihood security to nearly 72 crore people, the poor farmers, whose number comes to nearly one half of the population; who in turn provide food security to the other half (GOI, 2017).

India is currently ranked first in milk production in the world, accounting for 18.50 and 59.00 per cent of the world and Asian milk production, respectively, achieving an annual output of 187.70 million tonnes during 2018-19, as compared to 176.30 million tonnes during 2017-18, recording a growth of 6.47 per cent, as against an only 3.10 per cent increase in world milk production, during the same period. This much of milk is produced in India by 302.30 million cattle, inclusive of 192.50 million cattle and 109.90 buffaloes (NDDB, 2019).

The state of Kerala is a demographically and socially well advanced state located in the South Western region of India, with a human population of 3.34 crores which accounts for 2.53 per cent of the Indian population, even though it has got a mere 1.18 per cent of the total land area of India. Among the milk producing States in the country, Kerala ranked 14th, with a share of just 1.50 per cent of the total milk production in the country, had a milk production of 25.20 lakh tonnes in the year 2016-17 (Kerala State Planning Board, 2017).

However, it is noteworthy that even though the cattle population of Kerala as per the latest census, ie., 2012 census was only 14.30 lakhs, ie., 0.50 per cent of the Indian cattle population, it pulls its weight by thrice its strength when it comes to milk production. Inspite of the severe constraints imposed by the limited land availability and the ever swelling human population, the livestock sector in Kerala contributed 27.60 per cent of the agricultural GDP of the State during 2016-17 (Kerala State Planning Board, 2017).

Due to low price of all cash crops, especially rubber, the prospects of the agriculture sector in Kerala have become gloomy. This is where, animal husbandry, especially cattle rearing, assumes great significance, in the state, because milk is a commodity which is always having great demand in Kerala. The daily requirement of milk in Kerala was 75.46 lakh litres, while the availability was only 70.82 lakh litres, in the year 2016-17. That means that there exists a daily deficit of 4.64 lakh litres (Milma, 2017).

Feed cost is the most important factor which determines the profit or loss from a dairy enterprise. Nearly 70 – 75 per cent of the total cost of rearing a cow is contributed by feed cost alone. This is all the more important in Kerala where the cost of inputs such as feed and fodder are increasing day by day. This has necessitated a situation, wherein, we have to explore ways of providing feed in the form of complete diets.

Complete feed is a thoroughly blended mixture of concentrate and roughage ingredients formulated to meet the nutrient requirement of the animals (Owen 1984). Chacko *et al*. (2016) observed that paddy straw based complete rations formulated using conventional ingredients, with 25, 30 and 35 per cent NDF, showed significantly better performance than the conventional grass-concentrate system, with 35 per cent being the best. Raseel (2018) found that energy rich unconventional feed pineapple waste incorporated as a replacement for one third of the conventional energy source maize in paddy straw based complete feed showed significantly higher milk production and lower cost per kg milk production, than the conventional one.

Apart from energy, protein is also a critical nutrient as far as milk production is concerned. Protein in conventional rations is contributed by oil meals like soybean meal, which are costly. Therefore, the possibility of incorporation of locally available, protein rich unconventional feeds, to the extent possible, have to be explored. Moreover, the production performance and economics of lactating dairy

cows fed on grass based complete feeds in Kerala, also needs to be studied, as both the previous studies done were using paddy straw based complete rations.

Hence the present study was carried out with following objectives:

1. Study of *in vitro* digestion parameters of four unconventional protein rich feed ingredients
2. Evaluation of complete rations containing protein rich unconventional feed/ byproducts in early lactation dairy cows
3. Economics of production

2. REVIEW OF LITERATURE

2.1. PRESENT FODDER SCENARIO

2.1.1. 1ndia

India with only 2.29 per cent of the land area of the world, sustains nearly 17.40 per cent of world human population and 10.70 per cent of livestock (more than 510 million heads) creating a huge pressure on land, water and other resources (Datta, 2013). The green fodder requirement of India in the year 2019 was 827.19 million tonnes out of which 734.19 million tonnes were available and the deficit came to 11.24 per cent of the requirement. Regarding dry fodder, the requirement was 426.10 million tonnes out of which only 326.40 million tonnes were available and the rest 23.45 per cent were deficient (Roy *et al*., 2019).

2.1.2. Kerala

Prasad *et al*. (2017) conducted a study among the dairy farmers of Wayanad district of Kerala and reported that lack of fodder availability was one of the major constraints faced by them. The green fodder requirement of Kerala in the year 2019 was 3.76 million tonnes but only 0.09 million tonnes (2.40 per cent) were produced with a deficiency of 3.67 million tonnes (97.42 per cent). The dry fodder requirement of the state was 1.71 million tonnes but only 0.24 million tonnes (14.04 per cent) were produced with a deficit of 1.47 million tonnes (85.96 per cent) as reported by Roy *et al*. (2019).

2.2. COMPLETE FEED/ TOTAL MIXED RATION

Kishore *et al*. (2017) defined complete ration/total mixed ration (TMR) as a quantitative mix of all dietary components, blended thoroughly without giving any choice to the animal for selection of any specific ingredient.

2.2.1. Benefits of feeding complete rations

Gupta *et al*. (2014) observed that cross bred lactating cows fed on forage based complete rations had a significantly higher milk yield and digestibility coefficient of nutrients than those fed on conventional grass-concentrate ration.

Kennedy *et al*. (2015) reported that early lactation Holstein cows fed on TMR had a significantly higher dry matter intake (DMI) and milk yield than those fed on grass plus concentrate.

Konka *et al*. (2016) found that Murrah buffaloes fed on complete rations comprising of locally available crop residues such as maize stover, red gram and black gram straw had a significantly higher total volatile fatty acid (TVFA) production and better nitrogen balance than those fed on concentrate ration.

Wachirapakorn *et al*. (2016) reported that the use of ground corn cobs as the whole roughage source in complete feeds containing 60 per cent concentrate significantly improved nutrient intake and milk yield in lactating dairy cows than those fed on conventional grass-concentrate rations, in 40:60 ratio.

Beigh *et al*. (2017) opined on the basis of studies performed using agro industrial byproduct based complete feeds in lactating dairy cows that complete feeds provide continuous free choice availability of uniform feed mixture to ruminants and stabilise rumen fermentation so that maximum production at minimum feed cost can be obtained.

2.3. NON CONVENTIONAL FEED RESOURCES

Non conventional feed resources (NCFR) are those feeds that have not been traditionally used in rations for animals and consist of variety of feeds from crop residues and feeds of animal and industrial origin (Amata, 2015). She observed that compacting of several agro industrial byproducts in the form of complete feed blocks improves nutritive value of the rations.

2.3.1. Incorporation of non conventional feeds in complete rations for ruminants

Wanapat *et al*. (2000) reported that lactating Holstein Friesian cross bred cows fed on a cassava hay based complete ration at the rate of 1.70 kg per head per day had a significantly higher fat corrected milk yield, milk fat and protein percentage than those fed on the unsupplemented control ration. Roza *et al*. (2013)

reported that cassava leaf flour can be incorporated up to ten per cent level in complete rations for buffaloes without affecting their productivity.

Rathinavelu and Graziosi (2005) reported that coffee husk can replace up to 20 per cent of commercial concentrate in dairy cattle feeding with 30 per cent savings in cost. Xu *et al*. (2008) conducted a feeding trial in wethers and reported that substitution of wet brewer's grains, which formed 30 per cent of TMR, with wet barley tea grounds at 5, 10 and 15 per cent levels, significantly increased the digestibility coefficient of dry matter (DM) and gross energy.

Zebeli *et al*. (2008) observed that 30 to 33 per cent NDF was the optimum level of NDF in complete feeds and feeding of complete feeds containing NDF in the above range was essential for minimising the risk of sub acute ruminal acidosis, without impairing production responses in high yielding dairy cows. Boguhn *et a*l. (2010) reported that replacement of low neutral detergent fibre (NDF) maize with high NDF beet silage in TMR for dairy cows resulted in similar milk yield, milk fat and protein content.

Nagalakshmi *et al*. (2003) reported that cross bred calves fed on complete diets containing 40 per cent cotton straw in mash form had a better growth performance than those fed on concentrate mixture and cotton straw in a 60:40 ratio. Nagalakshmi *et al*. (2013) reported that red gram stalks could be incorporated in complete diets up to 40 per cent levels in Murrah buffaloes while levels higher than this decreased milk yield and nutrient digestibility. Raseel (2018) reported that paddy straw based complete rations containing maize can be successfully replaced by pineapple waste to provide one third of the energy requirement of lactating dairy cows.

2.4. INCORPORATION OF PROTEINACIOUS NCFRs IN CONVENTIONAL/ COMPLETE RATIONS

Koakhunthod *et al*. (2001) reported that lactating dairy cows fed on complete feed blocks containing cassava hay as a protein source at 30 per cent level had a

significantly higher DMI, milk yield and better digestibility coefficient of nutrients than those fed on conventional grass-concentrate system. Lunsin *et al*. (2012) found that lactating dairy cows fed on complete feeds containing cassava hay at 13 per cent level had a significantly higher DMI and milk yield than those fed on conventional grass-concentrate system.

Kondo *et al*. (2004) and Eruden *et al*. (2005) reported that green tea waste can be incorporated as a protein source up to five per cent level in complete feeds for lactating dairy cows. Tavares *et al*. (2005) reported that replacement of corn with coffee hulls at 25 per cent level in TMR of Holstein-Zebu cows, receiving adequate amount of concentrate feed stuffs, resulted in a significant decrease in milk production, even though coffee hull incorporation, reduced the cost per kg of TMR, by 19 per cent. These workers concluded that the lowering of feed cost on account of coffee hull incorporation did not compensate for the reduced milk yield, ultimately resulting in reduced profit. These workers attributed the presence of phytochemicals such as tannins and caffeine in coffee husk, which have got feed intake reducing characteristics, which might probably have resulted in reduced feed intake and subsequent reduction in milk yield and profit.

Badarinaa *et al*. (2013) performed an *in vitro* experiment by adding fermented coffee husk at levels of 0, 10, 20, 30 and 40 per cent in Napier grass based TMR having a total CP of 13.00 to 13.42 per cent and TDN of 61.00 to 65.00 per cent and reported that the dry matter digestibility significantly decreased with increase in level of incorporation above 20.00 per cent; with the values being 66.80, 59.19, 56.22, 52.21 and 47.51 per cent, for the 0, 10, 20, 30 and 40 per cent coffee husk incorporated groups, respectively, suggesting that coffee husk can be incorporated only upto 20 per cent level in the rations of dairy cows, with beneficial effects, after which it is detrimental. They observed that even though the pH and rumen ammonia were similar, the total volatile fatty acid, decreased significantly, with increase in the level of coffee husk in the TMR. These workers opined on the basis of a subsequent

in vivo experiment that presence of toxic principles such as tannin and caffeine in coffee husk, which have got the ability of reducing feed intake as well as reducing protein and carbohydrate digestion, might have contributed to negative effects, in levels of incorporation above 20 per cent.

Antaya *et al*. (2015) performed an experiment in early lactation Jersey cows by supplementing them with incremental amounts of *Ascophyllum nodosum* (ANOD) meal, a macroalga species which is a protein supplement having 20 per cent CP, in TMR having an average dry matter content of 60 per cent and reported that ANOD supplementation did not significantly increase the milk yield, even though it was numerically lower with increasing levels of ANOD supplementation. These researchers also observed that milk composition parameters such as fat, total solids, SNF, protein and MUN; yield of fat corrected milk, fat yield and protein yield were unaffected by ANOD supplementation. The digestibility of NDF and ADF was similar, even though the CP digestibility significantly decreased with increase in level of ANOD.

Choi *et al*. (2019) found that fermented spent instant coffee grounds could replace cotton seed at five per cent level in the rations of dairy cows. Sundarman *et al*. (2019) reported that coffee husk could be incorporated up to ten per cent level in the rations of Madura cattle with economic benefits.

2.5. *IN VITRO GAS* PRODUCTION TECHNIQUE AS A TOOL FOR EVALUATION OF NCFR BASED COMPLETE FEEDS FOR COWS

Chacko *et al*. (2015) reported that the *in vitro* corrected gas production, ME and digestible organic matter (DOM) value of cows fed on complete rations varying in NDF content from 25 to 35 per cent were similar. Banakar *et al*. (2016) conducted an *in vitro* gas production studies and found out the values of total gas production, ME and DOM values of protein rich un conventional feeds, viz., brewery waste, soya sauce waste, as 25.90, 6.82 ml per 200 mg; 54.63, 74.87 per cent and 5.32, 5.30 MJ per kg, respectively.

Lunagariya *et al*. (2017) conducted an *in vitro* study by adding exogenous fibrolytic enzyme in maize stover based complete feeds for lactating dairy cows and found a significantly higher organic matter (OM) digestibility, total gas production and ME. Raseel (2018) reported that the ME and DOM values of complete feeds comprising of the conventional ingredient maize and another complete feed in which one third of the maize was replaced by pineapple waste were similar.

Raseel *et al.* (2018) conducted an *in vitro* experiment to evaluate four energy rich unconventional feeds viz., pineapple, cashew apple, banana stem and jack fruit waste which were tested *in vitro* to estimate the ME, DOM, IVDN and CP. Based on the values obtained these four feeds were ranked on the basis of a four point ranking system and the feed having the highest aggregate score, viz., pineapple waste, was selected as the best feed which was further tested *in vivo*.

2.6. EFFECT OF FEEDING COMPLETE RATIONS ON PRODUCTION PARAMETERS

2.6.1. Body weight

Bargo *et al*. (2002) observed that early lactating dairy cows fed on an alfalfa based complete feed had a significantly higher body weight gain than those fed on a conventional grass-concentrate system. Hundal *et al*. (2004) reported that lactating dairy cows fed on complete feeds containing berseem and oat hay had a significantly higher body weight gain than those fed on a conventional hay-concentrate system.

Girdhar and Balaraman (2005) observed that cross bred dairy cows fed on berseem based TMRs containing three different levels of protein and energy; viz., 10 per cent CP and 55 per cent TDN, 12 per cent CP and 60 per cent TDN, 14 per cent CP and 65 per cent TDN, had a similar body weight, the average value being 453.40 kg. Lade *et al*. (2007) reported that cross bred dairy cows fed on an oats and berseem based complete feed showed a similar average body weight as that of those fed on a complete feed, without green fodder. Khan *et al*. (2010) reported that early lactation dairy cows fed on a TMR had a significantly higher body weight than those fed on

two different conventional systems, with wheat straw plus concentrate mixture in mash form and pellet form, respectively, both fed separately.

Kennedy *et al*. (2015) reported that the average body weight of lactating dairy cows fed on a complete feed containing 19 per cent citrus pulp was similar to that of cows fed on conventional-grass concentrate system. Scharen *et al*. (2015) reported that the body weight of lactating dairy cows fed on fodder maize based complete feeds was similar as that of those fed on conventional grass-concentrate system. Muhanned *et al*. (2017) found that lactating dairy cows fed on complete feeds containing maize and alfalfa hay as roughage source at 26.20 and 16.40 per cent level respectively, in TMR had a significantly higher body weight than those fed on grass-concentrate separately.

Raseel (2018) reported that the average body weight of early lactation dairy cows fed on a complete feed containing 1/3rd pineapple waste instead of maize in the conventional complete ration were similar, the values being 373.62 and 388.62 kg, respectively. Chacko *et al*. (2020) observed that the body weight of lactating dairy cows fed on complete rations with 25, 30 and 35 per cent NDF were 336.67, 338.33 and 357.00 kg, respectively, with cows in the 35 per cent NDF fed group having a significantly higher body weight than those fed on lower levels of NDF.

2.6.2. Dry matter intake

Girdhar and Balaraman (2005) observed that cross bred dairy cows fed on berseem based TMRs containing three different levels of protein and energy; viz., 10 per cent CP and 55 per cent TDN, 12 per cent CP and 60 per cent TDN, 14 per cent CP and 65 per cent TDN, had a similar dry matter intake (DMI), the average value being 3.74 kg per 100 kg body weight. Lade *et al*. (2007) reported that cross bred dairy cows fed on an oats and berseem based complete feed had a significantly higher DMI than those fed on a complete feed, without green fodder; with the average daily DMI, DMI per 100 kg body weight and DMI per kg metabolic body weight being 11.38, 10.59; 3.04, 2.71 and 0.14, 0.12 kg per day, respectively. Gupta *et al*. (2014)

reported that lactating dairy cows fed on complete rations with wheat straw as a roughage source had a significantly higher DMI than those fed on conventional grass-concentrate diet, the values being 11.36 and 10.16 kg, respectively.

Chacko (2015) reported that lactating dairy cows fed on complete feeds with varying levels of NDF, viz., 25, 30 and 35 per cent had similar DMI, the values being 13.93, 14.36 and 14.64 kg, respectively. Kennedy *et al*. (2015) reported that lactating dairy cows fed on complete feeds containing citrus pulp at 19 per cent level had a significantly higher DMI than those fed on conventional grass- concentrate system, the values being 21.60 and 19.80 kg, respectively. Scharen (2015) reported that lactating dairy cows fed on fodder maize based complete feeds had a significantly higher DMI than those fed on conventional grass-concentrate system, the values being 17.40 and 16.20 kg, respectively.

Purushothaman (2018) reported that cross bred cows fed on complete rations containing dhanwantharam thailam residue at five per cent level had a significantly higher DMI than those fed on complete ration containing rapeseed cake at five per cent level, the values being 6.97 and 5.92 kg, respectively. Raseel (2018) observed that the DMI of cows fed on complete rations in which 1/3rd of the energy source maize in the complete ration was replaced by pineapple waste were similar, the values being 15.24 and 15.27 kg, respectively.

2.6.3. Milk yield

Wanapat *et al*. (2000) reported that lactating Holstein Friesian cross bred cows fed on a cassava hay based complete ration at the rate of 1.70 kg per head per day had a significantly higher fat corrected milk yield than those fed on unsupplemented control ration, with the values being 6.80 and 7.10 kg, respectively. Bargo *et al*. (2002) observed that early lactating dairy cows fed on an alfalfa based complete feed had a significantly higher milk yield than those fed on a conventional grass-concentrate system, with the values being 28.50 and 21.60 kg, respectively. Lade *et al*. (2007) reported that cross bred dairy cows fed on an oats and berseem

based complete feed had a similar milk yield as compared to those fed on a complete feed, without green fodder; with the average daily milk yield being 9.15 and 8.43 kg per day, respectively.

Gupta *et al*. (2014) reported that lactating dairy cows fed on complete rations with wheat straw as a roughage source resulted in a significantly higher milk yield than those fed on conventional grass-concentrate ration. Chacko *et al*. (2016) reported that early lactation dairy cows fed on paddy straw based complete feeds with varying levels of NDF, viz., T1, T2 and T3 with 25, 30 and 35 per cent, respectively had a significantly higher milk yield than those fed on the conventional grass-concentrate system (T4), with the average daily milk yield values being 11.08, 11.81, 12.09 and 8.63 kg for cows in T1, T2, T3 and T4, respectively with T1, T2 and T3 being similar.

Muhanned *et al*. (2017) found that lactating dairy cows fed on complete feeds containing maize and alfalfa hay as roughage source at 26.20 and 16.40 per cent level respectively, in TMR had a significantly higher milk yield than those fed on a conventional-grass concentrate ration. Raseel (2018) reported that lactating dairy cows fed on complete feed containing 1/3rd pineapple waste instead of maize in the conventional ration had a significantly higher milk yield than those fed on complete feeds with conventional ingredients, the values being 12.94 and 11.94 kg, respectively.

2.6.4. Composition of milk

Wanapat *et al.* (2000) reported that lactating Holstein Friesian cross bred cows fed on a cassava hay based complete ration at the rate of 1.70 kg per head per day had a significantly higher milk fat than those fed on unsupplemented control ration, with the total solids (TS), solids not fat (SNF) and milk protein contents being similar. Hundal *et al.* (2004) reported that lactating dairy cows fed on complete feeds containing berseem and oat hay had a similar milk fat, protein and SNF content as that of cows fed on a conventional hay-concentrate system. Lade *et al*. (2007)

reported that milk composition parameters such as TS, fat, SNF and protein of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a complete feed, without green fodder; with the values being 14.57, 14.04; 4.84, 4.69; 9.73, 9.35 and 3.58, 3.54 g per cent, respectively.

Kelzer *et al.* (2009) observed that the milk urea nitrogen (MUN) content of lactating Holstein cows fed on TMRs incorporated with dried distiller's grains plus solubles at 15 per cent level were significantly higher than those fed on zero per cent level. Delany *et al*. (2010) reported that the milk fat, SNF, TS and milk protein of lactating dairy cows fed on a TMR alone and a pasture plus grain diet were similar. Ortega *et al*. (2014) reported that the milk fat and protein content of lactating dairy cows fed on a TMR containing fodder maize as roughage source at 34.90 per cent level without grazing was similar to those sent for daily grazing while Gulati (2017) reported that the TS and milk protein content of cows fed on a TMR containing fodder maize as roughage source without grazing were significantly lower than those sent for outdoor grazing. Kennedy *et al*. (2015) reported that the milk fat, TS, SNF and protein content of lactating dairy cows fed on a complete feed containing 19 per cent citrus pulp was similar to those fed on conventional-grass concentrate system.

Chacko *et al*. (2018) reported that the fat, TS, SNF and milk protein content of early lactation cows fed on complete rations with three different levels of NDF, viz., T1, T2 and T3 with 25, 30 and 35 per cent, were similar, the values being 4.60, 4.62, 4.51; 13.01, 13.06, 13.14; 8.45, 8.44, 8.51; 2.80, 2.92, 2.93 and 12.86, 10.84, 9.76 g per cent, respectively. These workers also reported that the MUN content decreased significantly, with increase in NDF content of the ration, the values being 12.50, 10.40, 9.35 mg per cent, for cows in groups T1, T2 and T3, respectively.

Raseel (2018) reported that the milk fat, TS, SNF, milk protein and MUN values of early lactation dairy cows fed on a complete feed containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 3.97,

4.20; 14.72, 14.39; 10.75, 10.17; 2.85, 3.07 g per cent and 12.11, 12.10 mg per cent, respectively.

2.6.4.1. Total yield of four per cent fat corrected milk, milk fat and protein

2.6.4.1.1. *Four per cent fat corrected milk (FCM) yield*

Lade *et al*. (2007) found that the average daily FCM yield of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a complete feed, without green fodder, with the values being 9.94 and 9.65 kg, respectively. Khan *et al*. (2010) observed that early lactation dairy cows fed on a TMR had a significantly higher FCM yield than those fed on two different conventional systems, with wheat straw plus concentrate mixture in mash form and pellet form, respectively, both fed separately, with the values being in the range of 4320.00 to 4935.60 kg. Chacko (2015) reported that early lactation dairy cows fed on complete rations with NDF levels of 25 (T1), 30 (T2) and 35 (T3) per cent had total FCM yields of 6187.92, 6888.12 and 6853.75 kg, respectively, with the high NDF groups, viz., T2 and T3 having a significantly higher FCM yield than those in T1, with T2 and T3 being similar.

2.6.4.1.2. Milk fat yield

Lade *et al*. (2007) observed that the average daily fat yield of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a complete feed, without green fodder, with the values being 0.44 and 0.41 kg, respectively. Chacko (2015) found that early lactation dairy cows fed on complete rations with NDF levels of 25 (T1), 30 (T2) and 35 (T3) per cent had total milk fat yields of 256.22, 288.88 and 287.19 kg, respectively, with the high NDF groups, viz., T2 and T3 having a significantly higher fat yield than those in T1, with T2 and T3 being similar.

2.6.4.1.3. Milk protein yield

Chacko (2015) observed that early lactation dairy cows fed on complete rations with NDF levels of 25 (T1), 30 (T2) and 35 (T3) per cent had total milk

protein yields of 164.41, 183.79 and 184.87 kg, respectively, with the high NDF groups, viz., T2 and T3 having a significantly higher fat yield than those in T1, with T2 and T3 being similar.

2.6.4.2. Off flavours in milk

Bartsch and Wickes (1979) performed an experiment in lactating cows by feeding them on graded levels of citrus meal, a fruit residue, at levels of 0.00, 0.70, 1.90 and 3.40 kg, as a supplement and observed that organoleptic gradings of milk from cows fed 3.40 kg of citrus meal was abnormal in flavour compared with milk from cows fed no citrus meal. Choi *et al.* (2019) reported that incorporation of fermented spent instant coffee grounds, at 10 per cent level on DM basis, in TMR for lactating dairy cows did not show any off flavor in milk.

2.6.5. Haemotological parameters

Delahoy *et al*. (2003) observed that cows fed on complete rations containing cracked corn at 66.50 per cent level had a significantly higher blood glucose and a significantly lower plasma urea nitrogen than those fed on complete rations containing steam flaked corn at 66.50 per cent level. Hundal *et al*. (2004) conducted a study in lactating dairy cows by feeding them on a conventional hay-concentrate feed and a complete feed and found that the BUN value was significantly higher in cows of the complete feed fed group than those of the conventional feed fed group, but glucose level was similar. Kim *et al*. (2012) reported that BUN value of Hanwoo steers fed on a complete ration containing 17.70 per cent of fermented feed was significantly lower while the blood glucose was similar to those fed on a conventional grass-concentrate diet.

Chacko *et al*. (2017a) reported that the serum glucose, BUN, plasma calcium and phosphorus levels of lactating dairy cows fed on complete rations with varying NDF levels viz., 25, 30 and 35 per cent, were similar, the values being 66.11, 66.10, 65.94; 7.82, 8.49, 8.64; 9.68, 9.87, 9.43 and 5.37, 5.47, 5.69 mg per 100ml, respectively. Purushothaman (2018) reported that the blood glucose, BUN and

plasma calcium content of cross bred cows fed on complete feeds containing dhanwantharam thailam residue and rape seed cake at five per cent level were similar but phosphorus level was significantly higher in rape seed based complete feed. Raseel (2018) found that the blood glucose, BUN, plasma calcium and phosphorus levels of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 62.67, 65.17; 12.75, 12.71; 10.83, 11.00 and 6.16, 6.57 mg per 100 ml, respectively. Nha *et al*. (2019) observed that the blood glucose and BUN values of lactating dairy cows fed on complete feed with 20 and 25 per cent NDF were similar.

2.6.6. Digestibility coefficient of nutrients

Hundal *et al*. (2004) reported that lactating dairy cows fed on berseem and oat hay based complete feeds had a significantly higher digestibility for organic matter (OM) and NDF than those fed on conventional rations, with the digestibility coefficients of CP and EE being similar. Girdhar and Balaraman (2005) observed that cross bred dairy cows fed on berseem based TMRs containing three different levels of protein and energy; viz., 10 per cent CP and 55 per cent total digestible nutrient (TDN), 12 per cent CP and 60 per cent TDN, 14 per cent CP and 65 per cent TDN; with incremental increase in the level of green fodder, berseem, viz., 25, 34 and 40 per cent, respectively, had a similar digestibility coefficient of DM, OM, EE, NDF and ADF; a significantly higher digestibility coefficient of CP, NFE and a significantly lower digestibility coefficient of CF; with increase in the level of CP, TDN and green fodder in TMR.

Saijpaul *et al*. (2005) found that lactating dairy cows fed on complete feeds containing green fodder as roughage source had significantly higher digestibility coefficient of DM, OM, crude fibre (CF) and nitrogen free extract (NFE) than those fed on complete rations containing dry fodder as roughage source. Lade *et al*. (2007) reported that the digestibility coefficients of DM, OM and CF of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a

complete feed, without green fodder; with the values being 63.12, 70.59; 63.72, 70.53 and 52.12, 59.83 per cent, respectively. However, the CP, EE and NFE digestibility were significantly lower in cows fed on complete feed with green fodder (57.97, 87.49 and 68.76 %) as compared to those fed without green fodder (63.92, 91.18 and 74.61 %).

Xu *et al.* (2008) reported that substitution of wet brewer's grains, which formed 30 per cent of TMR for wethers, with wet barley tea grounds at 5, 10 and 15 per cent levels, significantly increased the digestibility coefficient of DM and significantly decreased the digestibility coefficient of CP, EE and NDF. Khan *et al.* (2010) reported that early lactation dairy cows fed on a TMR had a significantly digestibility coefficient of DM than those fed on two different conventional systems, with concentrate mixture in mash and pellet form, plus wheat straw given separately, with the digestibility coefficient of OM, CF, CF, EE and NFE being similar.

Maulfair *et al.* (2011) found that the digestibility coefficient of DM of lactating dairy cows fed on complete rations with larger particle size were significantly lower than those fed on complete feeds having smaller particle size, with the digestibility coefficients of CP, CF, EE, NFE and NDF being similar. Gupta *et al.* (2014) reported that lactating dairy cows fed on a wheat straw based TMR had a significantly higher digestibility coefficient of DM and CP than those fed on conventional grass-concentrate system, with the digestibility coefficient of CF, EE and NFE being similar.

Chacko (2015) found out that the digestibility coefficients of DM, OM, CP, CF, EE, NFE and NDF of early lactation dairy cows fed on complete rations with NDF levels ranging from 25 to 35 per cent, were similar, with the ADF digestibility being significantly higher in the 30 and 35 per cent groups, as compared to 25 per cent group. Susanti *et al.* (2015) formulated a TMR with 47 per cent DM by adding Ramie waste, a fibre rich plant instead of 20 per cent soyabean meal in goats and reported that the goats fed on Ramie waste added TMR had a significantly lower

digestibility coefficient of DM, OM and NDF; as well a numerically lower, but non significant, digestibility coefficient of CF and ADF, than those fed on the unsupplemented control.

Purushothaman (2018) found that crossbred cows fed on complete feed containing dhanwantharam thailam residue at five per cent level had a significantly higher digestibility coefficient of EE and lower digestibility coefficient of CF and NFE than those fed on complete feed containing rape seed cake at five per cent level, with the digestibility coefficient of DM, OM and CP being similar. Raseel (2018) reported that the digestibility coefficient of DM, OM, CP, CF, EE, NFE, NDF and ADF of cows fed on a complete rations containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 78.18, 79.30; 79.74, 81.64; 73.53, 74.63; 54.29, 49.87; 63.90, 68.07; 62.97, 67.07, 56.94, 57.85 and 47.90 and 46.85 per cent, respectively.

Kajla *et al*. (2019) observed that the digestibility coefficient of DM, CP, NDF ADF and TDN of lactating dairy cows fed on wheat straw based TMRs were significantly higher than those fed on conventional feeds, with the digestibility coefficient of OM and EE being similar. Sarkar *et al*. (2019) found that lactating red Chittagong cows fed on a maize stover based TMR had a significantly higher digestibility coefficient of DM, OM, CP and lower digestibility coefficient of NDF than those fed on conventional grass-concentrate system, with the digestibility coefficient of ADF being similar.

2.6.7. Rumen fermentation parameters

Li *et al*. (2003) reported that Holstein steers fed on complete feeds containing beet pulp at 4.80 per cent level had significantly higher rumen ammonia nitrogen than those fed on conventional concentrate-roughage ration, with the rumen pH and TVFA being similar. Einarson *et al*. (2004) reported that the pH of rumen liquor of lactating dairy cows fed on complete feeds with variable length of chopped barley silage were in the normal range and similar to those fed on a conventional grass-concentrate

ration. Gupta *et al*. (2006) reported that the rumen ammonia content and TVFA of cross bred male cattle fed on a berseem based complete ration were significantly higher than those fed on a wheat straw based complete ration, without green fodder; with the rumen ammonia and TVFA values of animals in the two groups being 33.38, 22.44 mg per 100 ml and 86.47, 80.61 mmol per l, respectively.

Zebeli *et al*. (2008) observed that 30 to 33 per cent NDF was the optimum level of NDF in complete feeds and feeding of complete feeds containing NDF in the above range was essential for minimizing the risk of subacute ruminal acidosis, without impairing production responses in high yielding dairy cows.

Kelzer *et al.* (2009) found that the pH, TVFA and rumen ammonia nitrogen of lactating Holstein cows fed on complete feeds containing corn milling co-products at zero and 15 per cent level were similar. Susanti *et al*. (2015) reported that goats fed on Ramie waste added TMR had a similar, rumen ammonia concentration as compared to those than those fed on the unsupplemented control group, fed on soyabean meal as the protein source. Jeong *et al.* (2016) observed that the pH and TVFA of Hanwoo steers fed on complete feeds with and without Korean rice wine residue were similar. Konka *et al*. (2016) reported that Murrah buffaloes fed on complete rations comprising of locally available crop residues as roughage source had a significantly higher TVFA content than those fed on the conventional grass-concentrate ration.

Chacko *et al*. (2017b) reported that lactating dairy cows fed on complete rations with varying NDF levels viz., 25, 30 and 35 per cent had a similar rumen pH with the TVFA and rumen ammonia content increasing and decreasing linearly and significantly with increase in the NDF content of the ration, respectively, the values being 6.10, 6.10, 6.17; 73.71, 80.51, 83.68 meq per l and 26.02, 25.21, 22.83 mg per 100ml for pH, TVFA and rumen ammonia, respectively. Purushothaman (2018) reported that the pH, TVFA and rumen ammonia nitrogen of cross bred cows fed on complete rations containing dhanwantharam thailam residue and rapeseed cake at five

per cent level were similar. Raseel (2018) found that the pH, TVFA and rumen ammonia nitrogen of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 6.30, 6.30; 82.20, 82.04 meq per l and 25.87, 25.45 mg per 100ml for pH, TVFA and rumen ammonia, respectively.

2.6.8. Economics

Tozer *et al*. (2003) reported that feeding of TMR significantly improved milk yield and was found to be more economical than conventional feeding in lactating dairy cows. Rathinavelu and Graziosi (2005) reported that coffee husk can replace upto 20 per cent of commercial concentrate in dairy cattle feeding with 30 per cent savings in cost.

Pandya *et al*. (2009) reported that the cost of feed per kg body weight gain of crossbred calves fed on complete rations containing sugarcane bagasse at 30 per cent level were lower than those fed on conventional grass-concentrate system. Raseel (2018) reported that the cost of milk production for lactating dairy cows fed on complete ration containing 1/3rd pineapple waste instead of maize in the conventional ration was lower and the values were Rs.34.22 and 36.82, respectively. Early lactation dairy cows given complete diets having 25, 30 and 35 per cent NDF, had a similar cost per kg milk production, the values being Rs.28.46, 28.28 and 29.22, respectively (Chacko *et al*., 2019).

3. MATERIALS AND METHODS

3.1. *IN VITRO* STUDY

Four locally available unconventional feed ingredients which are rich source of protein, viz., tapioca leaf meal (*Manihot esculenta)*, tea waste (*Camellia sinensis*), coffee husk (*Coffea arabica*) and pepper waste (*Piper nigrum*) were procured. These feeds were tested *in vitro* by the *in vitro* gas production technique (IVGPT) of Menke and Steingass (1988) to estimate the metabolisable energy (ME) and digestible organic matter (DOM).

The *in vitro* degradable nitrogen (IVDN) content of the feeds was determined by the procedure of Raab *et al*. (1983). The crude protein (CP) content of the above feeds was determined by standard procedure (AOAC 2016).

3.1.1. In *vitro* gas production - *Calculation of ME, DOM and IVDN*

The prediction equation for the calculation of ME and DOM from gas production data are given below:

ME (KJ/ kg DM) = 1.24+0.146 x gas (ml/200 mg DM)+0.007 x CP*+0.0224 x EE*

DOM (%) = 14.88+0.889 x gas (ml/200 mg DM) + 0.45 x CP*+0.65 x TA*

*CP (%), EE (ether extract in %) and TA (total ash in %)

$$\text{IVDN}^{**} = \frac{\text{A-(A-B) C-(ammonia nitrogen of blank)}}{\text{(C-D)}}$$

$$\frac{}{\text{Total nitrogen of feeding stuff incubated}}$$

**A = mg of ammonia nitrogen after 24 hr incubation, with no carbohydrate added; B = mg NH3-N after 24 hr incubation with carbohydrate added; C = ml gas production in 24 hr, with no carbohydrate added; D = ml of gas production in 24 hr, with carbohydrate added.

3.1.2. Scoring system

A four point scoring system as depicted in Table 1, first devised by Raseel (2018) was used for ranking the unconventional feeds tested in the *in vitro* study. Based on the values obtained for each of the above four parameters¸ individual scores

were assigned for each of the four unconventional feeds tested and the feed ingredient having the highest aggregate score was selected as the best feed.

3.2. *IN VIVO* STUDY

3.2.1. Ration formulation

Two experimental complete rations, T1 with 13 per cent CP and 65 per cent TDN on DM basis and T2 with 1/3rd of the CP in T1 being replaced by the unconventional feed ingredient identified from *in vitro* study were formulated. The two experimental rations T1 and T2 were isonitrogenous and isocaloric and were formulated as per the recommendations of ICAR (2013). The ingredient composition and calculated nutrient content of the experimental rations are given in Tables 2 and 3, respectively. The ration was prepared at the Feed Mill of School of Animal Nutrition and Feed Technology, College of Veterinary and Animal Sciences Mannuthy and taken to CBF Thumboormuzhi.

3.2.2. Animals: selection and grouping

Twelve cross bred dairy cows yielding approximately 18 litres of milk per day and within 10 days of lactation were selected from the Cattle Breeding Farm (CBF), Thumboormuzhi. They were divided into two groups of six animals each, as uniformly as possible with regard to milk yield and body weight. The animals were given individual pens to facilitate individual feeding and watering. The animals were checked for signs of health prior to the trial. Five days adaptation period was given prior to the 90 days feeding trial for the cows to get accustomed with the new feeding and management.

3.2.3. Housing and management

The animals were maintained under uniform managemental conditions prevailing at CBF, Thumboormuzhi. All the animals were given individual stalls with sufficient space and proper ventilation. Standard deworming schedule was followed against ecto and endo parasites. Daily cleaning of animals and shed as well as regular disinfection of shed was carried out. The animals were checked constantly and monitored for signs of health. Strict cleaning of manger was done on daily basis and manger was properly dried prior to feeding. *Ad libitum* water was provided for each animal with constant monitoring.

3.2.4. Feeding trial

3.2.4.1. Dry matter intake

Animals were provided *ad libitum* feed. The feed offered and feed residue was measured on daily basis. Samples of feed offered and residue left in 24 hours interval was used for dry matter analysis and thus dry matter intake of individual cows were calculated.

3.2.4.2. Body weight

Body weight of cows were recorded on fortnightly basis. Body weight was recorded in the morning, before feeding to measure accurate bodyweights.

3.2.4.3. Milk yield

The animals were milked twice a day, at 5 AM in the morning and 2 PM in the afternoon. The milk recording data was used to calculate the daily milk yield for each animal throughout the experimental period.

3.2.4.4. Milk composition and incidence of off flavor, if any

Morning and evening milk samples were collected from individual animals every fortnight and analysed for fat (IS: 1224, 1977), total solids (TS), protein (AOAC, 2016) and milk urea nitrogen (Bector *et al*., 1998). The solids not fat (SNF), was calculated as follows, SNF (%) = TS (%) - Fat (%)

The presence or absence of off flavour of milk, if any, was also noted.

3.2.4.5. Yield of four per cent fat corrected milk, fat yield and protein yield

From the data on fat, TS and protein, the total yield of four per cent fat corrected milk, fat yield and protein yield were calculated using the respective formulae, as given below:

Four per cent fat corrected milk yield (kg) = 0.4M + 15F, where M = kg milk and F = kg fat

$$\text{Fat yield (kg)} = \frac{\text{Fat percentage x milk yield (kg)}}{100}$$

$$\text{Protein yield (kg)} = \frac{\text{Protein percentage x milk yield (kg)}}{100}$$

3.2.4.6. Proximate analysis

Samples of complete feed, residue and dung were analysed for proximate principles as per the methods of Association of Official Analytical Chemists (AOAC, 2016). Samples

of feed and dung were analysed for neutral detergent fibre (NDF) and acid detergent fibre (ADF) as per the methods of Van Soest *et al.* (1991). The calcium and phosphorus content of the feed was determined by standard procedure (AOAC, 2016).

3.2.4.7. Blood analysis

Blood samples were collected from each animal at the beginning and end of the trial. 10 ml of blood was collected from jugular vein through puncture method in serum vials. The serum vials kept in slanting position were soon brought to laboratory and centrifuged at 3000 rpm for 15 minutes. The serum samples were separated and were stored in small plastic vials (2ml) at a temperature of -20°C for further analysis.

The stored serum samples were used to estimate glucose (GOP-PAP method), blood urea nitrogen (modified Berthlot method), calcium (modified OCPC method) and inorganic phosphorus (phosphomolybdate method) using the standard kits supplied by Agappe Diagnostics, Maharashtra, India.

3.2.4.8. Digestibility trial

A digestibility trial of five days duration was conducted towards the end of the feeding trial by total collection method. The feeding schedule was same in digestibility trial period as the week prior to it. Weighed amount of feed was offered at regular intervals and residue was collected on 24 hour basis. Each animal in separate pen was assigned a bucket for collection of dung voided by it. Dung voided by each animal was collected immediately and was stored in respective buckets. Amount of feed offered, balance feed and amount of dung voided by each animal was recorded. Samples of feed, dung and residue were collected on 24 hour basis.

A proportionate sample of dung from each animal was taken after thorough mixing and stored at a temperature of -20°C in double lined polythene bags. The samples of five days were pooled together and the pooled samples were analysed for proximate principles. From the data on feed intake, dung output and nutrient composition of feed and dung, digestibility coefficient of various nutrients were calculated for each animal.

3.2.4.9. Rumen fermentation parameters

Rumen liquor was collected from all the animals towards the end of the feeding trial by using stomach tube. The rumen fluid was checked for pH (Orion Star A series pH meter-Thermo Scientific) soon after collection and was preserved for estimation of total volatile fatty acid (Barnett and Reid, 1957) and rumen ammonia nitrogen (Beecher and Whitten, 1970).

3.2.4.10. *In vitro* gas production of experimental complete rations

The *in vitro* total gas production from the experimental diets was also determined using IVGPT (Menke and Steingass, 1988) to estimate the ME and DOM content in them, as described earlier.

3.2.4.11. Economics

From the data gathered on various parameters, the cost of feed per kg milk produced was worked out.

3.3. Statistical analysis

All the data generated in the above experiment were statistically analysed as per Snedecor and Cochran (1994) by analysis of variance (ANOVA) technique, using statistical package for the social sciences (SPSS) version 21.0. For comparison of groups independent T-test were used.

Table 1: Score sheet for ranking the unconventional feeds of *in vitro* study

Parameter tested *in vitro*	Unit (on DM basis)	Range of value	Score
CP	Per cent	0-2.5 2.5-5 5-7.5 7.5-10 10-12.5 12.5-15 >15	0 + ++ +++ ++++ +++++ ++++++
ME	MJ/ kg DM	<4 4-5 5-6 6-7 7-8 8-9 >9	0 + ++ +++ ++++ +++++ ++++++
DOM	Per cent	<40% 40-50 50-60 60-70 70-80 80-90 >90%	0 + ++ +++ ++++ +++++ ++++++
IVDN as per cent of total nitrogen	Per cent	<40% 40-50 50-60 60-70 70-80 80-90 >90%	0 ++++ +++++ ++++++ +++ ++ +

Table 2: Ingredient composition of the two experimental complete rations

Ingredient	T1 (kg)	T2 (kg)
Maize	18.00	29.00
Coffee husk	0.00	20.00
De-oiled rice bran	32.00	14.50
Soya bean meal	6.00	4.00
Coconut cake (De-oiled)	12.00	7.00
Green grass (Hybrid Napier- CO3)	27.50	20.00
Vegetable fat (palm oil)	2.50	3.50
Dicalcium phosphate	1.50	1.50
Salt	0.50	0.50
Total	100.00	100.00

* To every 100 kg of complete feed, 100g of Vitamin AD_3E supplement (containing 10,00,000 I.U of Vitamin A, 2,00,000 I.U of Vitamin D_3 and 1,00,000 I.U of Vitamin E, 50g of trace mineral mixture (KERAMIN FORTE) and 50g of toxin binder (CURATOX) were added.

Table 3: Calculated nutrient content of the two experimental complete rations, % on DM basis

Nutrient	T1	T2
Crude protein (CP)	13.03	13.05
Neutral detergent fibre (NDF)	36.11	36.57
Acid detergent fibre (ADF)	24.77	26.05
Total digestible nutrient (TDN)	65.56	65.59

4. RESULTS

The results obtained in the present study are given under the following headings:

The photographs of the four selected protein rich unconventional feeds are depicted in plate 1.

4.1. *IN VITRO* STUDY

The data of *in vitro* study and CP content of the feeds are presented in Table 4; the scores obtained are given in Table 5 and represented in Figure 1.

4.2. CHEMICAL COMPOSITION

The data on chemical composition of the complete rations used in the experiment are given in Table 6. The CP content (in per cent) of the two experimental rations used was 15.25 and 14.89, respectively on dry matter basis. The NDF content of the rations used were 35.39 and 35.40 per cent, respectively on dry matter basis.

4.3. BODY WEIGHT

The data on fortnightly body weight of cows maintained on the two experimental rations are given in Table 7 and represented in Figure 2.

4.4. DRY MATTER INTAKE (DMI)

The details of average daily DMI of cows fed on the two treatments are shown in Table 8. The comparison between the DMI per 100 kg body weight and DMI per kg metabolic body weight of cows, fed on the two experimental rations are given in Table 9. The graphical representations of the same are given in Figures 3 and 4, respectively.

4.5. MILK PRODUCTION

The data shown in Table 10 and Figure 5 indicate the average daily milk yield of cows fed on the two dietary treatments.

4.6. MILK COMPOSITION

The composition of milk, viz., fat, total solids (TS), solids not fat (SNF), protein and milk urea nitrogen (MUN) from experimental cows, collected at

fortnightly intervals are presented in Tables 11 and graphically represented in Figures 6, 7, 8, 9, 10, respectively.

4.7. OFF FLAVOUR IN MILK

The presence or absence of off flavor in milk are presented in Table 12.

4.8. YIELD OF FOUR PER CENT FAT CORRECTED MILK, FAT AND PROTEIN YIELD

The data on yield of four per cent fat corrected milk, fat and protein yield are presented in Tables 13 and represented in Figures 11, 12, 13, respectively.

4.10. HAEMATOLOGICAL PARAMETERS

The haematological values, viz., glucose, BUN and plasma mineral parameters, viz., Ca and P, are presented in Table 14 and graphically represented individually in Figures 14 and 15.

4.11. DIGESTIBILITY COEFFICIENTS OF NUTRIENTS

The composition of dung and digestibility coefficients of nutrients of experimental cows are given in Tables 15 and 16, respectively, with the latter being presented in Figure 16.

4.12. RUMEN FERMENTATION PARAMETERS

The data on rumen fermentation parameters, viz., pH, total volatile fatty acids (TVFA) and rumen ammonia levels in rumen liquor collected from cows of the two dietary treatments, at the end of the experiment are given in Table 17 and Figure 17.

4.13. *IN VITRO* GAS PRODUCTION

The data on *in vitro* gas production from the experimental rations are shown in Table 18 and Figure 18.

4.14. ECONOMICS

The data on total DMI, total feed intake and cost per kg milk production are given in Table 19 and Figure 19.

Tea waste

Tapioca leaf meal

Coffee husk

Pepper waste

Plate 1: Photograph of four protein rich unconventional feed tested *in vitro*

Table 4: *In vitro* characteristics and crude protein content of four protein rich unconventional feed ingredients

Feed	ME (MJ/kg)	DOM (%)	IVDN (% of total N)	CP (%)
Tea waste	5.59±0.12	44.63±0.34	38.52±0.28	21.84
Coffee husk	5.67±0.08	45.31±0.22	45.24±0.38	11.82
Tapioca leaf meal	5.44±0.05	43.51±0.36	37.73± 0.47	22.38
Pepper waste	3.39±0.15	32.89±0.58	36.21± 0.51	13.34

Table 5: Score card after assigning grade to each parameter

Feed	ME (MJ/kg)	DOM (%)	IVDN (% of total N)	CP (%)	Total
Tea waste	2	1	0	6	9
Coffee husk	2	1	4	4	11
Tapioca leaf meal	2	1	0	6	9
Pepper waste	1	0	0	5	6

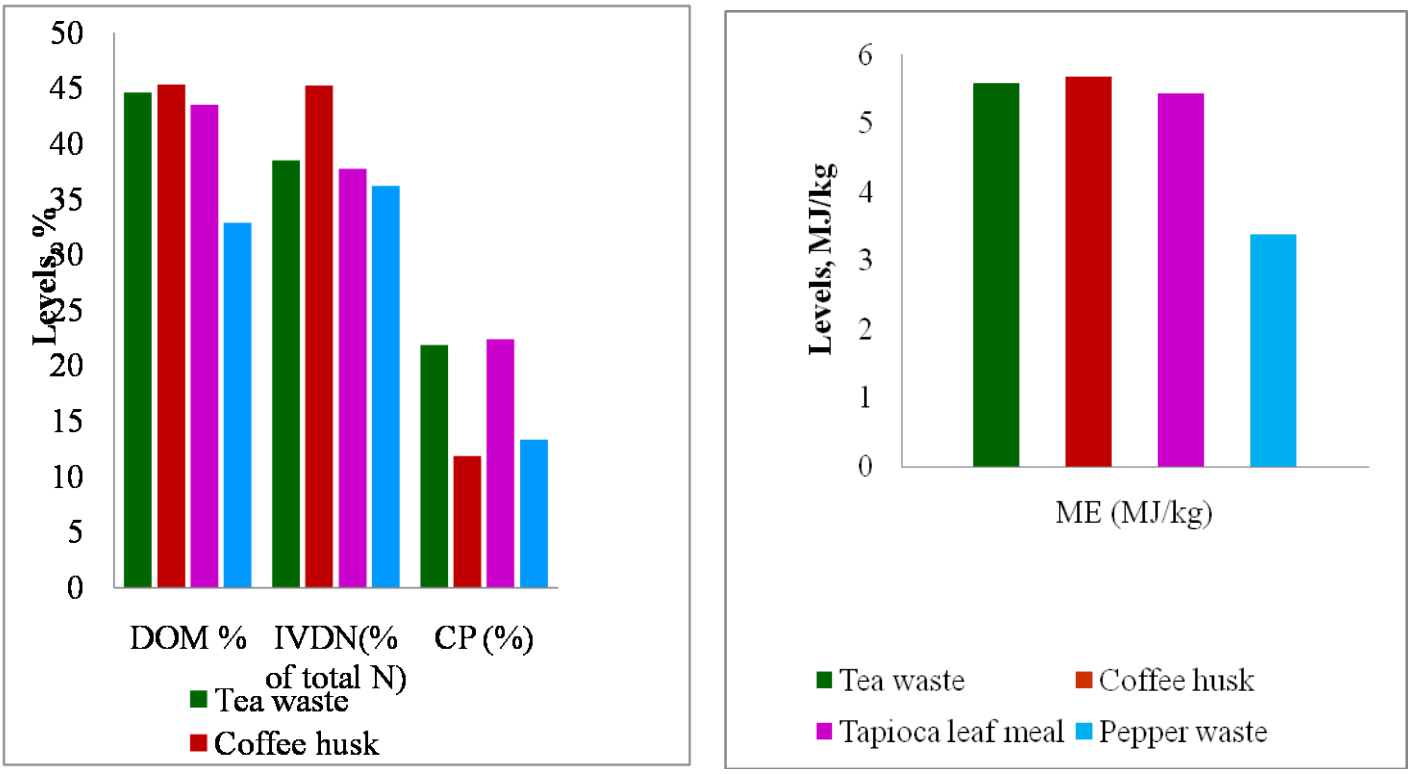

Figure 1*: In vitro* characteristics and CP of four protein rich unconventional feed ingredients

Table 6: Chemical composition of complete rations (%, on DM basis)

Nutrient	T1	T2
Dry matter, % as a % of total DM	52.92	48.30
Crude protein	15.25	14.89
Crude fibre	17.08	17.58
Ether extract	2.90	2.36
Total ash	10.13	10.02
Nitrogen free extract	54.64	55.15
Acid insoluble ash	7.48	7.33
Neutral detergent fibre (NDF)	35.39	35.40
Acid detergent fibre (ADF)	24.45	26.37
Calcium	0.93	0.91
Phosphorus	0.41	0.44

Table 7: Fortnightly body weight* (kg) of cows maintained on the two experimental rations

Fortnight	Mean ± SE		t-value (p value)
	T1	T2	
Initial	391.22±14.18	389.47±15.03	0.085^{ns} (0.934)
1	396.37±11.79	412.23±15.16	0.826^{ns} (0.429)
2	407.20±11.52	421.30±15.72	0.723^{ns} (0.486)
3	412.27±11.57	424.70±15.63	0.639^{ns} (0.537)
4	417.00±12.60	427.93±15.57	0.546^{ns} (0.597)
5	421.53±13.11	431.83±15.09	0.515^{ns} (0.618)
6	423.69±13.43	433.50±15.16	0.484^{ns} (0.639)

*Average of six values

ns- Non significant at 5 per cent level

Table 8. Fortnightly average daily dry matter intake* (kg) of cows maintained on the experimental rations

Fortnight	Mean ± SE		t-value (p-value)
	T1	T2	
1	14.76^{a}±0.12	12.79^{b}±0.26	6.909** (<0.001)
2	15.76^{a}±0.02	13.74^{b}±0.15	12.75** (<0.001)
3	15.75^{a}±0.04	14.09^{b}±0.10	15.90** (<0.001)
4	15.68^{a}±0.05	14.08^{b}±0.10	13.807** (<0.001)
5	15.66^{a}±0.02	14.03^{b}±0.11	14.421** (<0.001)
6	15.66^{a}±0.03	13.98^{b}±0.12	14.299** (<0.001)

*Average of six values

** Significant at 1 per cent level

a, b: means with different superscripts in the same row differ significantly (P<0.01)

Table 9: DMI per 100 kg body weight* and per kg metabolic body weight* of the animals maintained on the experimental rations

Parameter	T1	T2	t value (p value)
DMI, kg/100 kg body weight	3.76^{a}±0.10	3.25^{b}±0.14	2.94* (0.03)
DMI, kg/kg metabolic body weight	0.17^{a}±0.003	0.15^{b}±0.004	3.64* (0.01)

*Average of six values

*Significant at 5 per cent level

a, b: means with different superscripts in the same row differ significantly (P<0.05)

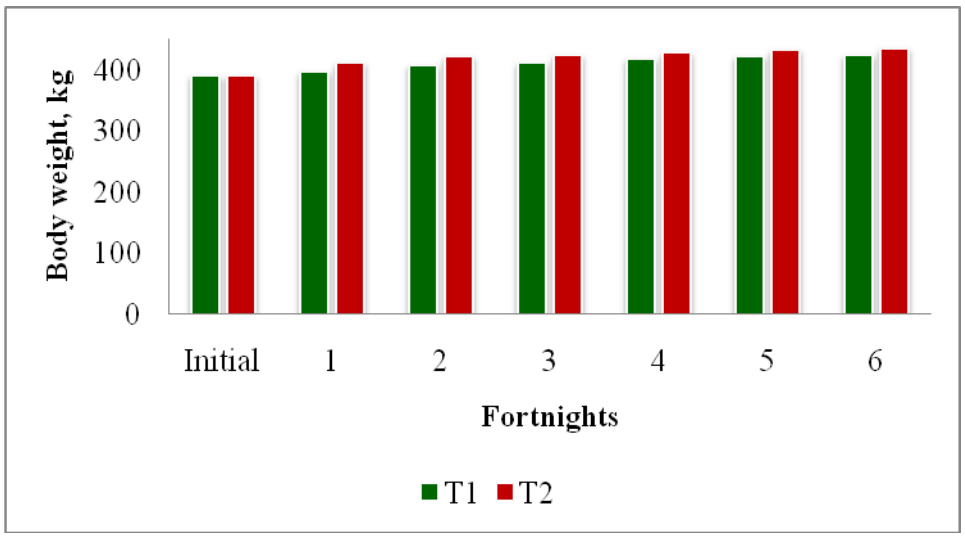

Figure 2: Fortnightly average body weight of cows fed on the experimental rations, kg

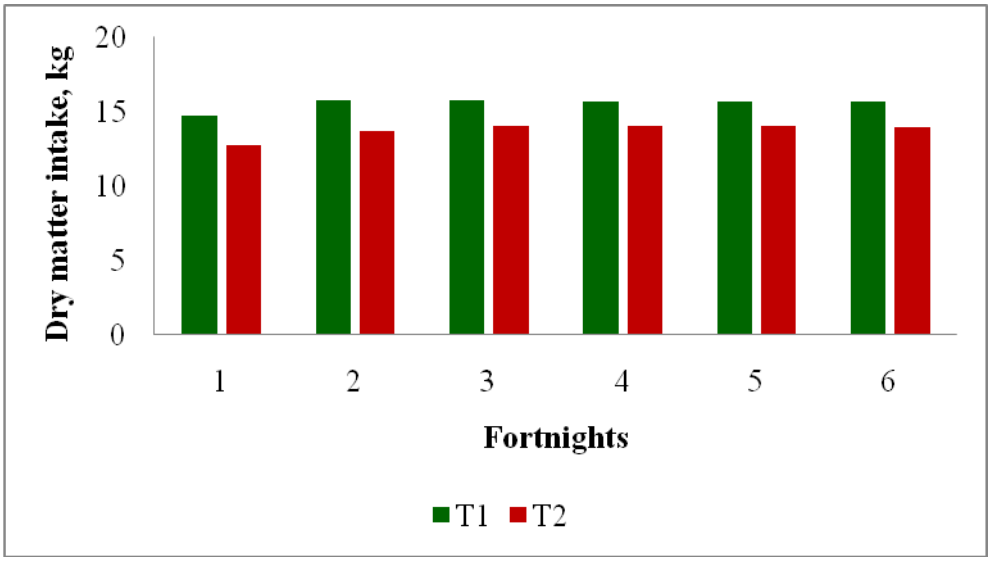

Figure 3: Average daily DMI of cows fed on the experimental rations, kg

Table 10: Fortnightly average daily milk yield* (kg) of cows maintained on the experimental rations

Fortnight	Mean±SE		t-value (p-value)
	T1	T2	
Initial	17.97±1.47	18.03±1.67	0.300^{ns} (0.977)
1	19.12±0.82	16.89±1.43	1.352^{ns} (0.206)
2	19.29±0.74	15.88±1.66	1.875^{ns} (0.090)
3	19.16±0.68	15.53±1.58	2.106^{ns} (0.061)
4	18.51±0.85	14.77±1.56	2.105^{ns} (0.062)
5	18.10±0.84	15.17±1.51	1.693^{ns} (0.121)
6	17.45±0.803	14.87±1.51	1.509^{ns} (0.162)

*Average of six values

ns- Non-significant

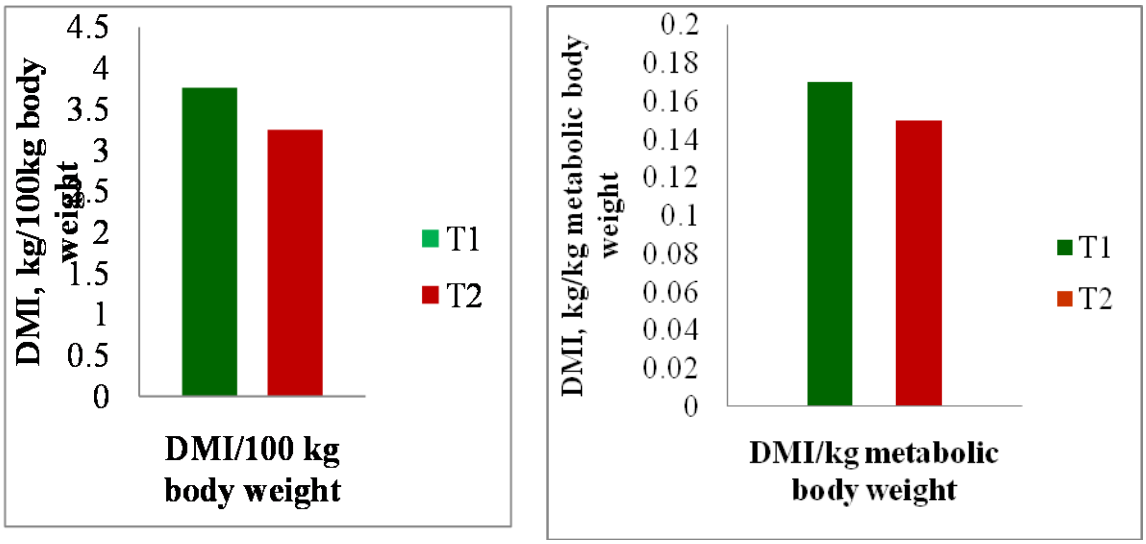

Figure 4: DMI per 100 kg body weight and per kg metabolic body weight of cows fed on the two experimental rations, kg

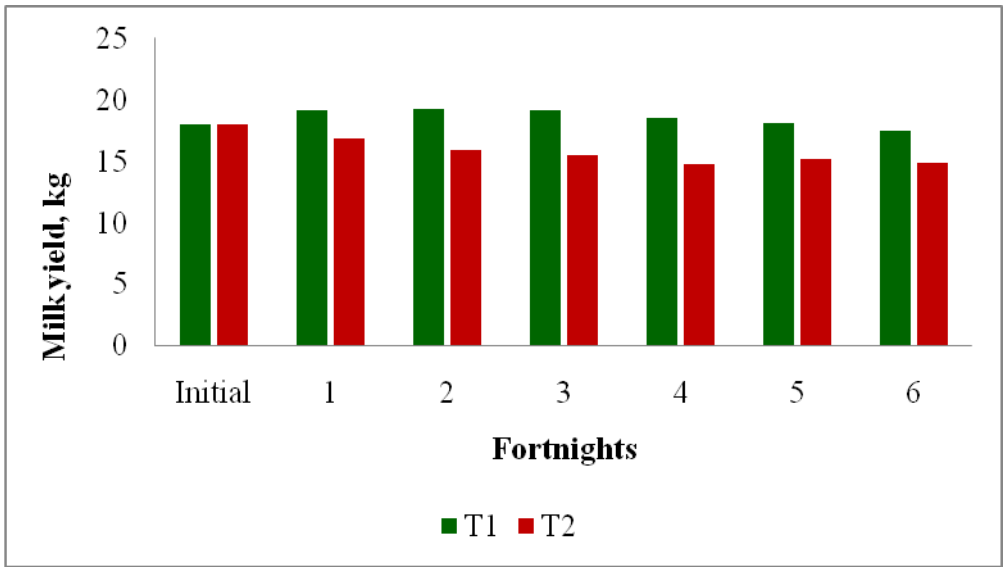

Figure 5: Fortnightly average daily milk yield of cows maintained on the experimental rations, kg

Table 11: Composition of milk from cows maintained on the two experimental rations

Parameters	Treatment	Fortnight						t-value (p-value)
		1	2	3	4	5	6	
Fat (g%)	T1	4.30± 0.26	4.31± 0.31	4.37± 0.25	4.38± 0.25	4.27± 0.33	4.12± 0.33	0.150^{ns} (0.884)
	T2	4.43± 0.19	4.42± 0.21	4.51± 0.15	4.04± 0.19	4.21± 0.16	4.34± 0.17	
Total solids (g%)	T1	12.93± 0.22	12.45± 0.26	12.57± 0.29	12.45± 0.34	12.54± 0.28	12.45± 0.37	0.141^{ns} (0.890)
	T2	12.34± 0.22	12.57± 0.24	12.62± 0.29	12.20± 0.26	12.29± 0.20	12.39± 0.26	
SNF (g%)	T1	8.54± 0.09	8.64± 0.08	8.53± 0.06	8.52± 0.05	8.62± 0.09	8.63± 0.09	0.659^{ns} (0.525)
	T2	8.28± 0.10	8.45± 0.09	8.36± 0.13	8.48± 0.16	8.58± 0.15	8.53± 0.12	
Protein (g%)	T1	3.12± 0.28	3.15± 0.03	3.14± 0.01	3.15± 0.03	3.14± 0.01	3.13± 0.04	0.579^{ns} (0.575)
	T2	3.03± 0.03	3.11± 0.03	3.05± 0.04	3.14± 0.04	3.10± 0.05	3.16± 0.05	
Milk urea nitrogen (mg%)	T1	9.83± 0.08	9.50± 0.19	9.55± 0.24	9.48± 0.24	9.41± 0.31	9.57± 0.27	0.299^{ns} (0.771)
	T2	9.80± 0.23	9.65± 0.35	9.73± 0.27	9.43± 0.35	9.40± 0.30	9.43± 0.35	

*Average of six values

ns -Non-significant

Table 12: Flavour of milk from cows maintained on the two rations

Flavour of milk	T1	T2
Off flavour	Nil	Nil

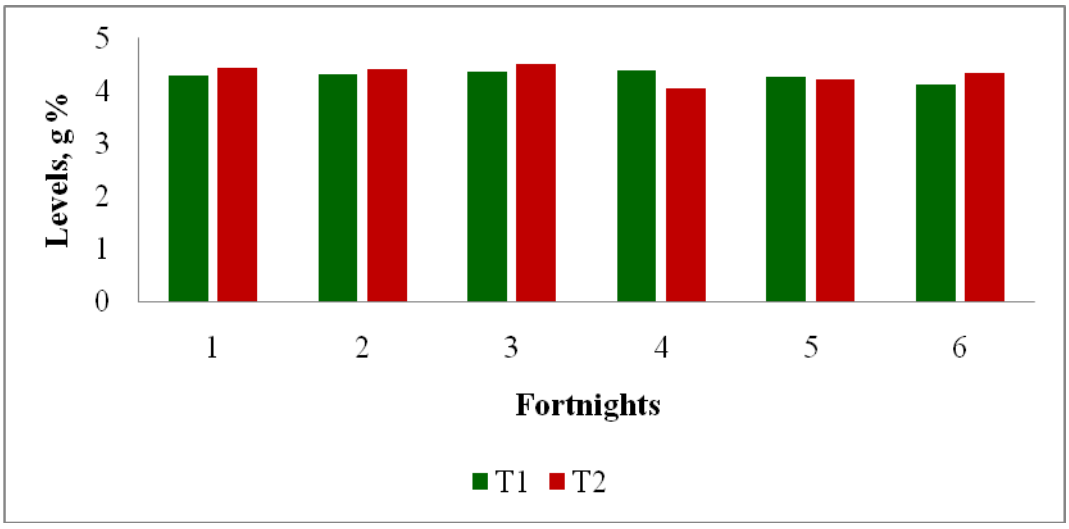

Figure 6: Fortnightly average milk fat content of cows maintained on the experimental rations, g %

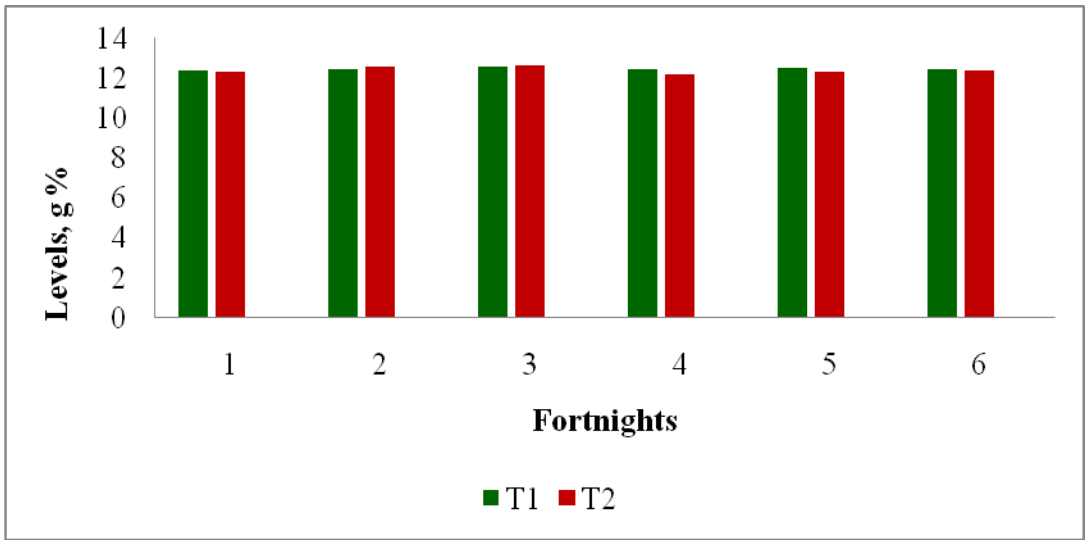

Figure 7: Fortnightly average total solids content of milk of cows maintained on the experimental rations, g %

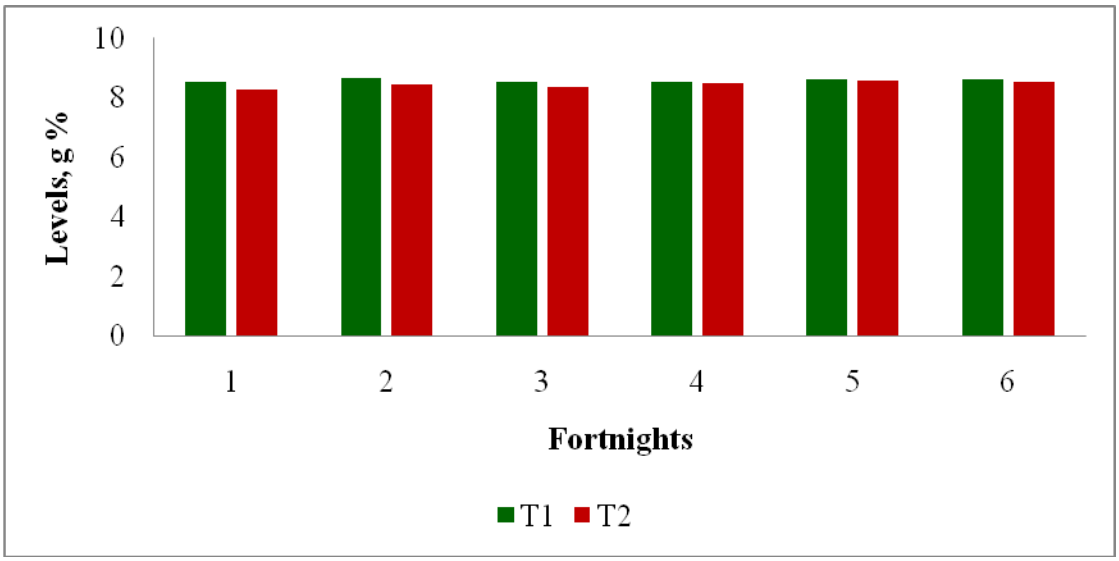

Figure 8: Fortnightly average SNF content of milk of cows maintained on the experimental rations, g %

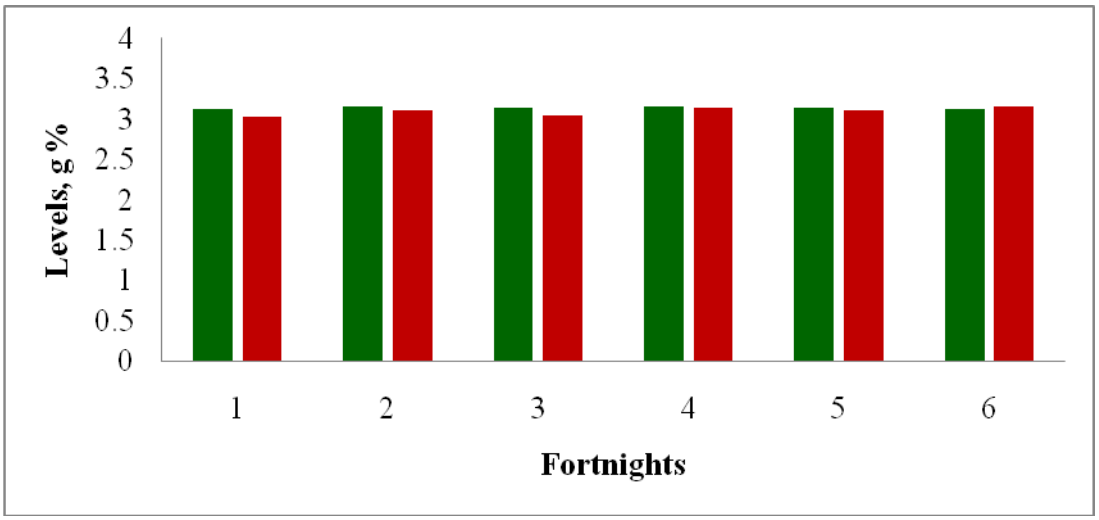

Figure 9: Fortnightly average milk protein content of milk of cows maintained on the experimental rations, g %

Table 13: Yield of four per cent fat corrected milk (FCM), fat and protein yield of cows maintained on the two experimental rations, kg

Parameter	Fortnight	T1	T2	Parameter	Fortnight	T1	T2	Parameter	Fortnight	T1	T2
Average FCM/ cow/day[1]	1	19.98	17.98	Average fat yield/ cow/day[1]	1	0.82	0.75	Average protein yield/ cow/day[1]	1	0.60	0.51
	2	20.19	16.88		2	0.83	0.70		2	0.61	0.49
	3	20.22	16.72		3	0.84	0.70		3	0.60	0.47
	4	19.57	14.86		4	0.81	0.60		4	0.58	0.46
	5	18.83	15.65		5	0.77	0.64		5	0.57	0.47
	6	17.76	15.63		6	0.72	0.65		6	0.55	0.47
Average FCM/ group/fortnight[2]	1	1678.35	1510.27	Average fat yield/ group/fortnight[2]	1	69.06	62.85	Average protein yield/ group/fortnight[2]	1	50.11	42.99
	2	1695.71	1417.96		2	69.84	58.96		2	51.04	41.48
	3	1698.76	1404.32		3	70.33	58.83		3	50.54	39.79
	4	1643.47	1248.12		4	68.10	50.12		4	48.98	38.96
	5	1581.98	1314.42		5	64.92	53.65		5	47.74	39.50
	6	1492.18	1312.78		6	60.39	54.21		6	45.88	39.47
Total FCM		**9790.45**	**8207.87**	**Total fat yield**		**402.65**	**338.62**	**Total protein yield**		**294.29**	**242.19**
Average FCM/ group/ fortnight	**Mean ± SE**	**1631.74[a] ± 33.09**	**1367.98[b] ± 38.45**	**Average fat yield/ group/ fortnight**	**Mean ± SE**	**67.11[a] ± 1.56**	**56.44[b] ± 1.88**	**Average protein yield/ group/ fortnight**	**Mean ± SE**	**49.05[a] ± 0.80**	**40.37[b] ± 0.64**
t-value (p value)		5.200** (< 0.001)		t-value (p value)		4.376** (0.001)		t-value (p value)		8.532** (< 0.001)	

[1] Calculated on the basis of fortnightly average daily milk yield and average fat content,of individual
[2] Calculated on the basis of fortnightly average daily milk yield and average fat content,of group
*Average of six values
** Significant at 1 percent level
a, b: means with different superscripts in the same row differ significantly (P<0.01)

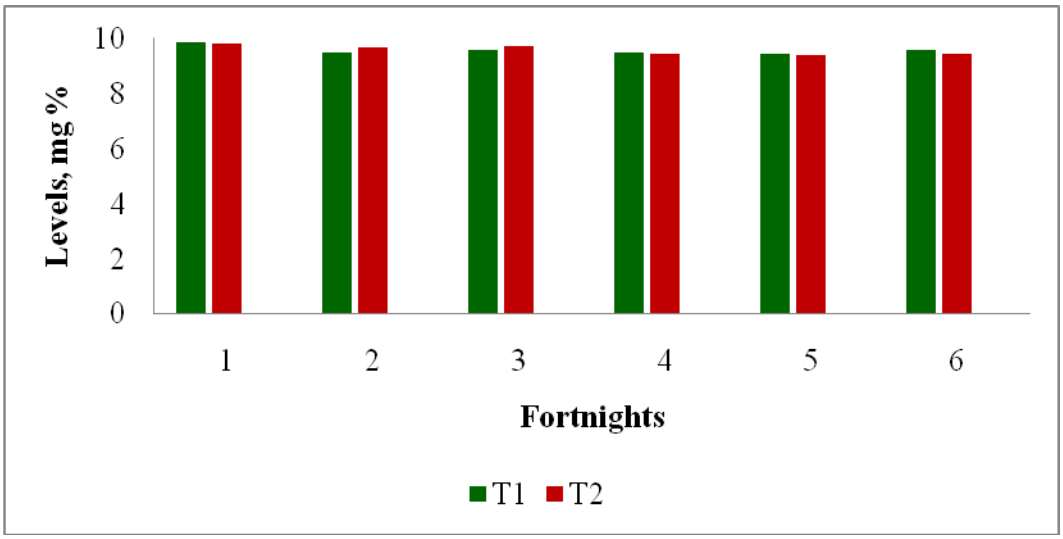

Figure 10: Fortnightly average MUN content of milk of cows maintained on the experimental rations, mg%

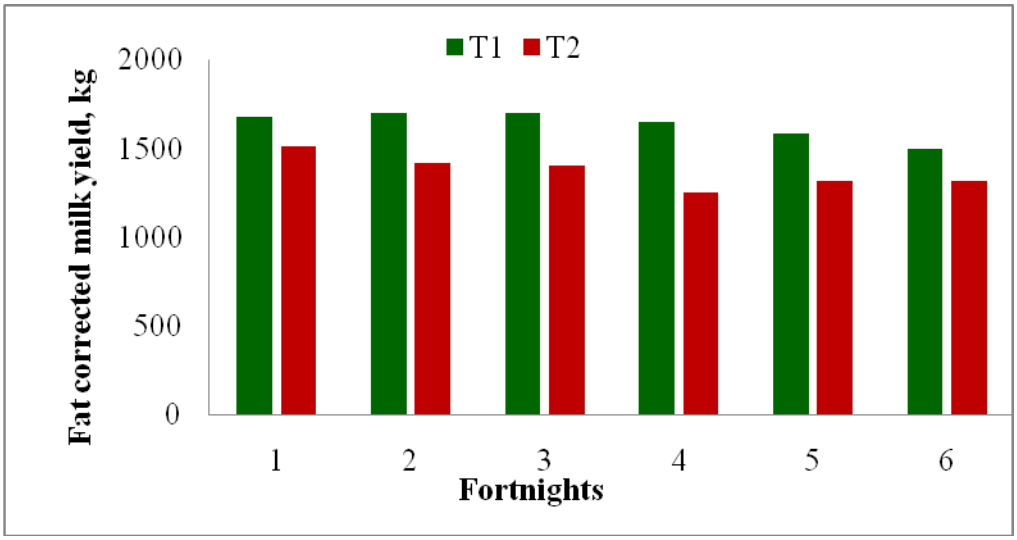

Figure 11: Fortnightly fat corrected milk yield of cows maintained on experimental rations, kg

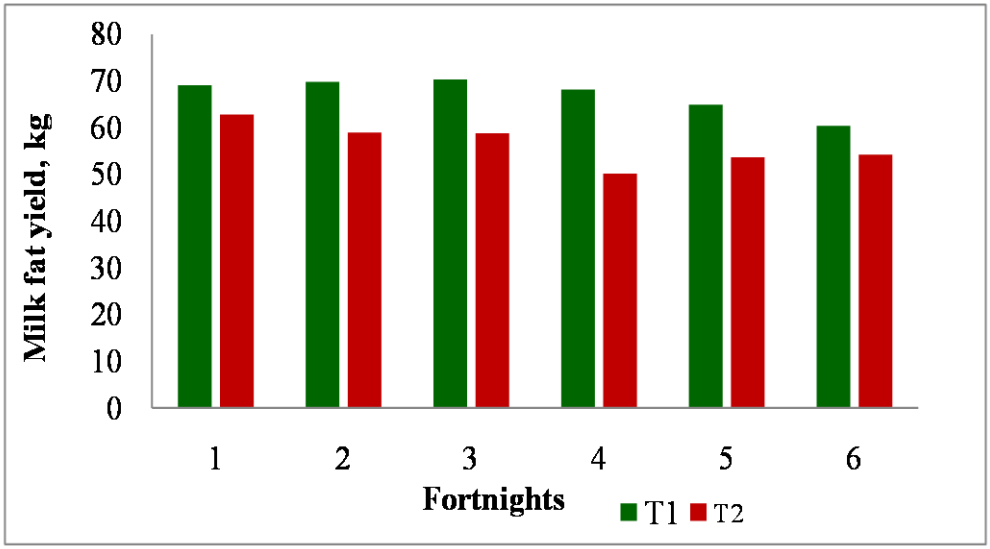

Figure 12: Fortnightly average fat yield from cows maintained on experimental rations, kg

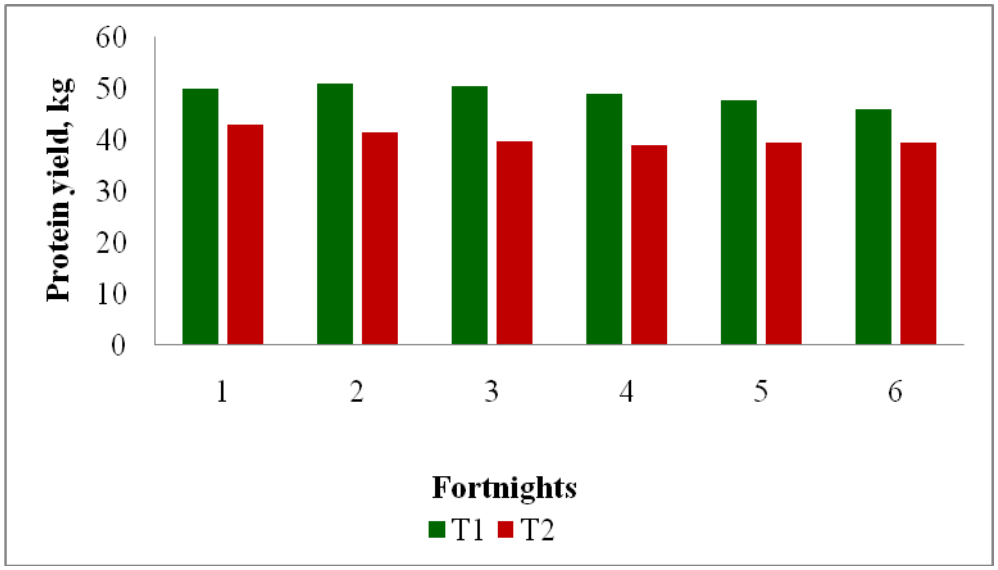

Figure 13: Fortnightly average protein yield from cow maintained on the experimental rations, kg

Table 14: Haematobiochemical parameters of cows maintained on the two experimental rations

Parameter	Group	Mean± SE		p value (t value)
		1st day	90th day	
Blood glucose (mg/100ml)	T1	51.01±0.93	49.22±1.07	
	T2	52.04±1.19	50.13±1.0	1.28^{ns} (0.25)
Blood urea Nitrogen (mg/100ml)	T1	16.86 ±1.19	16.95± 3.00	0.38^{ns} (0.19)
	T2	23.17 ±5.22	24.36± 3.23	0.44^{ns} (0.18)
Calcium (mg/100ml)	T1	8.75±0.15	8.75±0.15	0.030^{ns} (0.26)
Phosphorous (mg/100ml)	T2	8.54±0.16	8.54±0.16	0.78^{ns} (0.46)

*Average of six values

ns- Non-significant

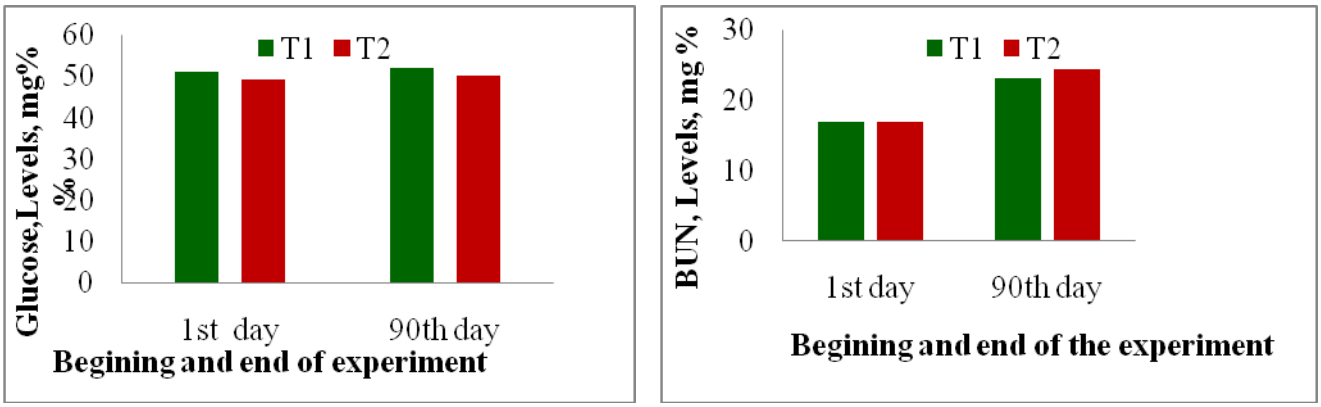

Figure 14: Average blood glucose and BUN content of cows maintained on the experimental rations at the beginning and end of experiment, mg %

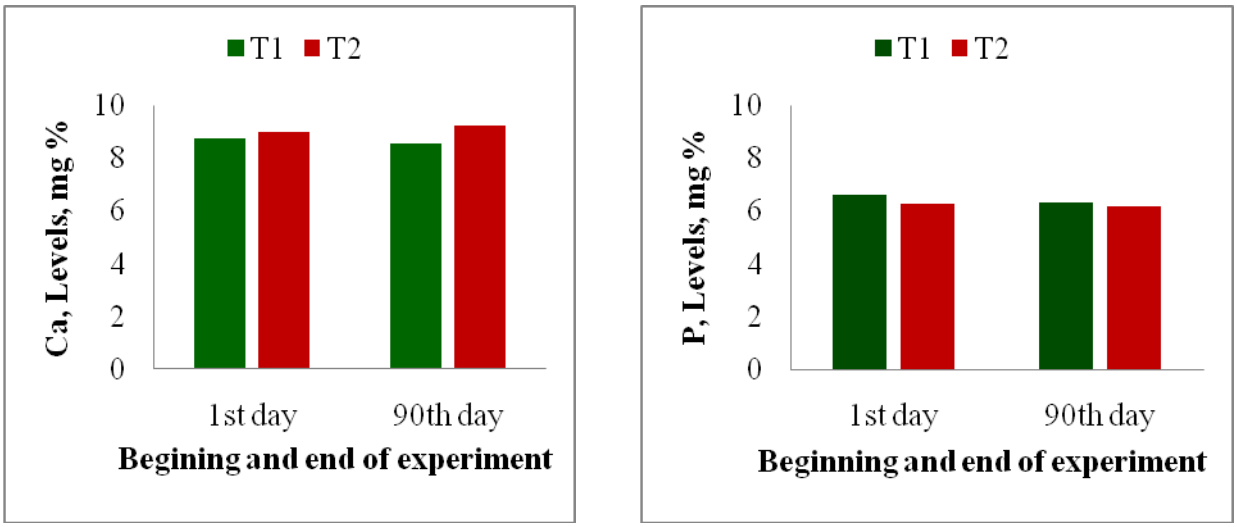

Figure 15: Average plasma mineral parameters (calcium and phosphorus) of cows maintained on the experimental rations at the beginning and end of experiment, mg %

Table 15: Chemical composition* of dung from cows maintained on the two experimental rations (%, on DM basis)

Nutrient	T1	T2
Dry matter	18.97±0.90	21.69±0.82
Crude protein	12.78±0.14	12.48±0.36
Crude fibre	21.47±0.24	23.10±0.25
Ether extract	0.23±0.03	0.20±0.03
Total ash	18.30±0.36	16.21±0.46
Nitrogen free extract	47.21±0.64	48.00±0.52
Organic matter	81.70±0.37	83.79±0.46
Acid insoluble ash	13.02±0.21	10.33±0.25
Neutral detergent fibre (NDF)	35.10±0.45	34.98±0.40
Acid detergent fibre (ADF)	24.17±0.90	26.60±0.82

*****Average of six values

Table 16: Digestibility coefficients* of nutrients of cows fed on the two experimental rations (%, on DM basis)

Nutrient	T1	T2	t value (p-value)
Dry matter	65.33^{a}±1.02	50.78^{b}±0.83	11.06^{**} (<0.01)
Crude protein	69.85^{a}±1.11	58.77^{b}±1.05	7.24** (<0.01)
Crude fibre	54.75^{a}±1.81	35.33^{b}±1.14	9.10** (<0.01)
Ether extract	97.12^{a}±0.27	95.80^{b}±0.21	3.83** (0.003)
Organic matter	70.61^{a}±1.09	58.75^{b}±0.79	8.79** (<0.01)
Nitrogen free extract	68.92^{a}±1.21	57.13^{b}±1.11	7.19** (<0.01)
NDF	64.35^{a}±1.25	51.37^{b}±0.95	8.28** (<0.01)
ADF	64.76^{a}±1.25	50.33^{b}±1.22	8.26** (<0.01)

* Average of six values

** Significant at 1 per cent level

a, b: means with different superscripts in the same row differ significantly (P<0.01)

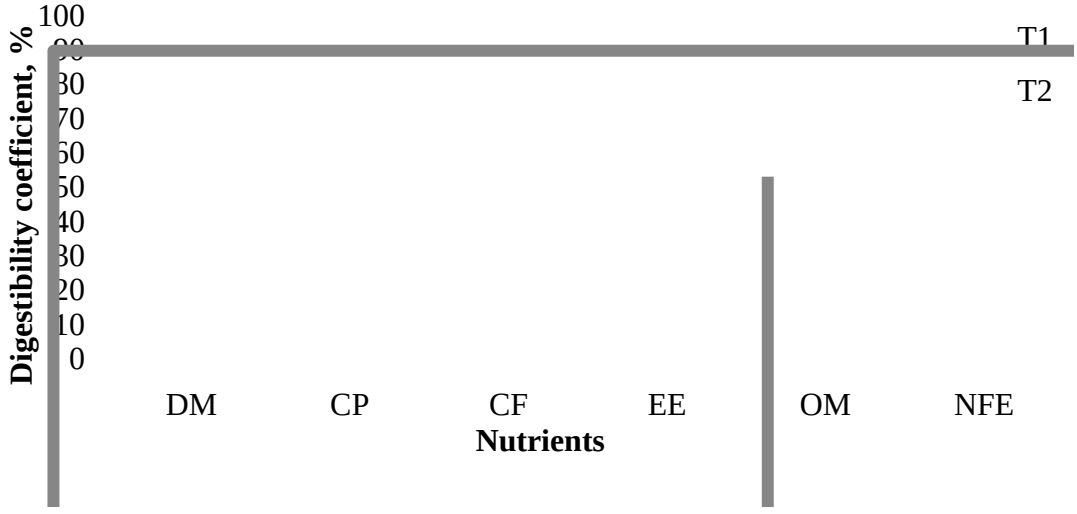

Figure 16: Digestibility coefficients of nutrients of cows fed on the two experimental rations, %, on DM basis

Table 17: Rumen fermentation parameters of cows maintained on the two experimental rations

Group	T1	T2	t value (p value)
pH	6.72±0.10	6.77±0.04	0.44^{ns} (0.67)
TVFA (meq/l)	82.71^{a}±0.87	84.94^{b}±0.31	2.43* (0.05)
Rumen ammonia (mg/100ml)	25.39±0.21	25.27±0.19	0.42^{ns} (0.67)

*significant at 5 % per cent level; ns Non-significant at 5 % per cent level

a, b: means with different superscripts in the same row differ significantly (P<0.05)

Table 18: *In vitro* gas production from the two experimental rations

Group	T1	T2	p value (t value)
Corrected gas (ml/200mgDM)	28.67±0.21	28.42±0.21	3.35^{ns} (0.07)
ME (MJ/kg DM)	5.74±0.02	5.74±0.03	0.11^{ns} (0.92)
DOM (%)	43.51±0.23	43.24±0.14	4.21^{ns} (0.08)

ns-Non significant at 1 per cent level

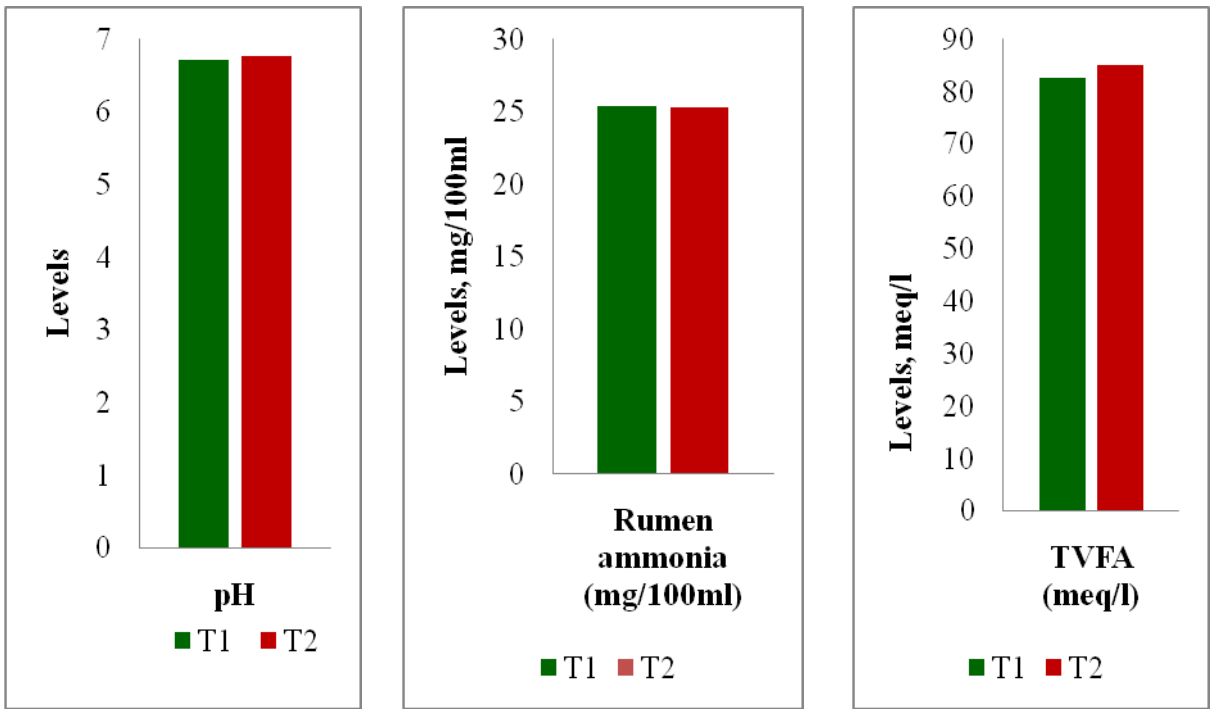

Figure 17: Rumen fermentation parameters of cows fed on the two experimental rations

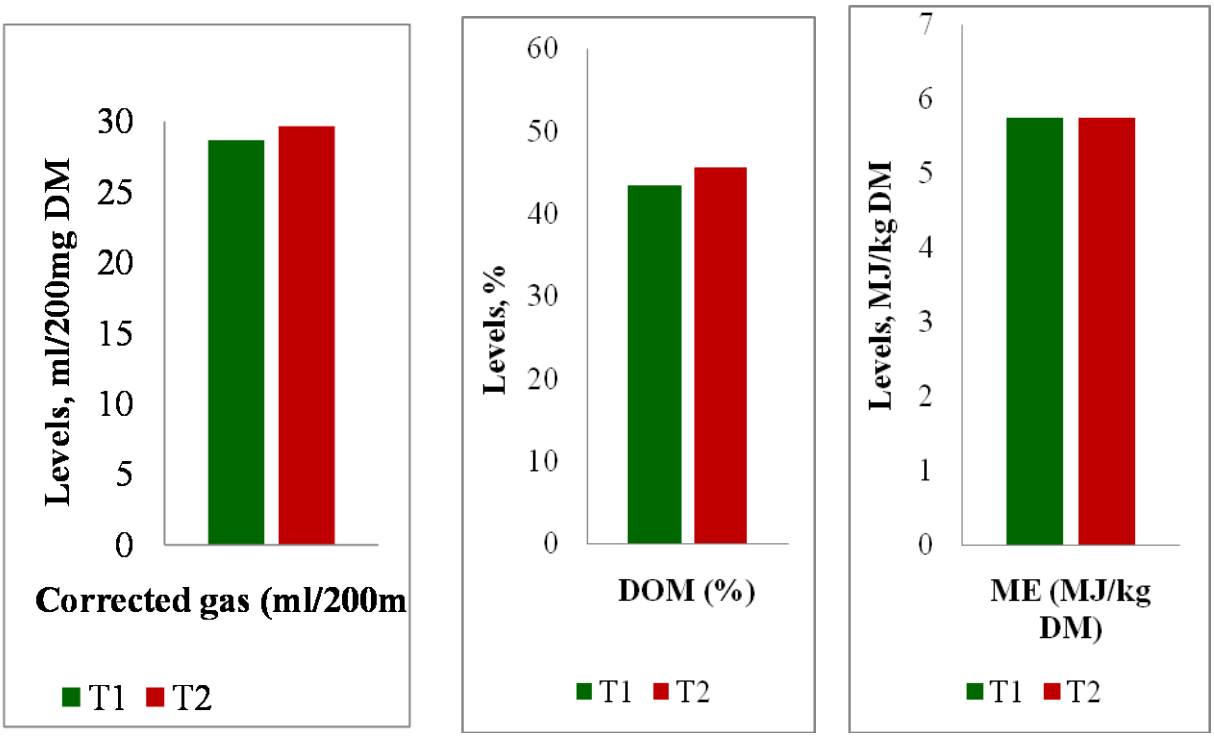

Figure 18: *In vitro* gas production from the two experimental rations

Table 19: Economics

Parameters	T1	T2
Total dry matter intake, kg	8393.31	7446.46
Total milk produced, kg	10034.80	8381.20
Dry matter intake per kg milk produced, kg	0.84	0.89
Cost per kg DM of feed, Rs.	45.40	46.19
Cost per kg feed (fresh basis), Rs.	24.02	22.21
Total feed cost, Rs.	3,81,014.31	3,43,951.987
Cost per kg of milk produced, Rs.	37.97	41.04

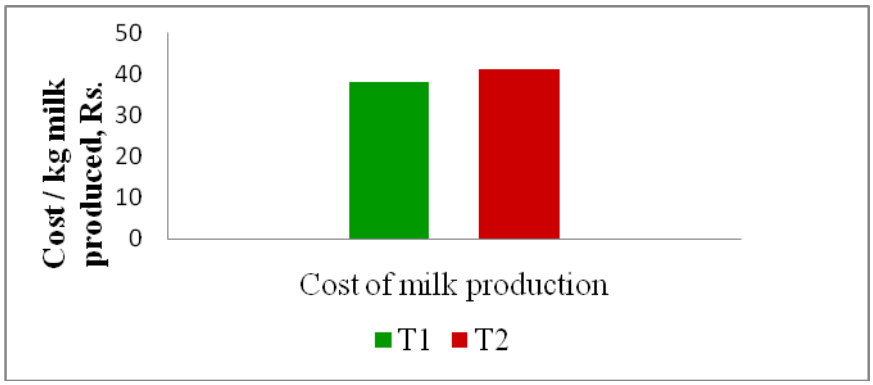

Figure 19: Cost of production of milk from cows maintained on the experimental rations

5. DISCUSSION

5.1. *In vitro* study

The ME, DOM, IVDN and CP of the four protein rich unconventional feed ingredients were 5.59, 5.67, 5.44, 3.39 MJ/kg DM; 44.63, 45.31, 43.51, 32.89 per cent; 38.52, 45.24, 37.73, 36.21 per cent and 21.84, 11.82, 22.38, 13.34 per cent for tea waste, coffee husk, tapioca leaf meal and pepper waste, respectively. The total scores were 9, 11, 9 and 6 for tea waste, coffee husk, tapioca leaf meal and pepper waste, respectively. Based on the aggregate total score, coffee husk was selected for the *in vivo* study as it was the best in the *in vitro* experiment.

5.2. *In vivo* study

5.2.1. Chemical composition of rations

The crude protein (CP) level of the two experimental rations T1 and T2 fed to the cows were 15.25 and 14.89 per cent, respectively (Table 6). The dry matter (DM) content of the above rations were 52.92 and 48.30 per cent, respectively (Table 6). As per ICAR (2013) the CP requirement of a lactating dairy cow, weighing 400 kg and yielding 15 kg of milk per day with four per cent fat was 1.88 kg. The total daily dry DM requirement of such a cow calculated as per ICAR (2013) was 16.92 kg. Therefore, to ensure 1.88 kg of CP from this 16.92 kg of dry matter intake (DMI), the ration should contain 11.11 per cent of CP. The CP content of the rations used in the present study, are higher than this as well as adequate as it also includes an allowance for cows which consume less than the expected 16.92 kg of dry matter, ie., 4.23 per cent of the body weight, which is practically difficult to achieve during the early stages of lactation. NRC (2001) recommends that a cow weighing 454 kg and yielding 15 kg of milk per day should be provided with a ration containing 16.60 per cent CP. The CP content of the rations, in the present study are lower than the NRC recommendations, but the NRC recommendations are for cows having greater body weight and yielding more milk than the cows used in the present study.

The calculated TDN content of the two rations T1 and T2 fed to the cows in this study were 65.56 and 65.59 per cent, respectively (Table 3). As per ICAR (2013) the total TDN requirement of a cow in early lactation weighing 400 kg and yielding 15 kg of milk per day with four per cent fat was 8.22 kg of TDN. To ensure this much of TDN intake from 16.92 kg of DMI, the total ration should contain 49 per cent of TDN. The TDN content of the rations used in this study is therefore adequate and includes an allowance for cows which consume less than the expected amount of dry matter. The TDN values of the rations in this experiment were lower than the NRC (2001) recommendations, which stipulate a higher TDN level of 78 per cent for the total ration.

The NDF content of the rations, T1 and T2 fed to the cows was 35.39 and 35.40 per cent, respectively and the ADF content of the rations T1 and T2 fed to the cows was 24.45 and 26.37 per cent, respectively (Table 6). These values are in accordance with NRC (2001) of USA which recommends that dairy cows, should be fed with rations containing a minimum of 17 to 21 per cent acid detergent fibre (ADF) and 25 to 33 per cent NDF. These rations are also in accordance with the specification of ICAR (2013) which states that the minimum dietary NDF content of the TMR should be 33.00 per cent.

Girdhar and Balaraman (2005) formulated three berseem based TMRs containing three different levels of protein and energy; viz., 10 per cent CP and 55 per cent TDN, 12 per cent CP and 60 per cent TDN, 14 per cent CP and 65 per cent TDN, for their study in cross bred dairy cows, yielding 8 to 9 kg of milk, on an average. The CP and TDN of the third group was similar to those used in this experiment. Gupta *et al*. (2006) prepared a berseem based TMR with 14.89 per cent CP for their study in crossbred cattle, which was comparable to the present study. The total CP and TDN content of Napier grass based TMRs containing fermented coffee husk at 0, 10, 20, 30 and 40 per cent levels, prepared by Badarinaa *et al*. (2013) for

their study ranged from 13.00 to 13.42 and 61.00 to 65.00 per cent, respectively, which was in accordance with the levels used in this study.

The CP and TDN level of the three experimental complete rations with varying levels of NDF, viz., 25, 30 and 35 per cent, formulated by Chacko (2015) in a study conducted in early lactation dairy cows were 12.23, 12.94, 12.18 and 64.50, 64.44, 64.28 per cent, respectively. Raseel (2018) prepared two paddy straw based complete feeds, one comprising of the conventional ingredient maize alone (15.84 per cent CP, 64.61 per cent TDN and 35.24 per cent NDF) and another in which one third of the maize was replaced by pineapple waste (16.66 per cent CP, 64.30 per cent TDN and 35.68 per cent NDF), in his study conducted in early lactation cows. The CP, TDN and NDF levels used in these studies are also comparable to the present one.

Gupta *et al*. (2006) prepared a berseem based TMR with 35.94 per cent DM for their study in crossbred cattle. Lade *et al*. (2007) formulated an oats and berseem based complete feed with 46.85 per cent DM for their study in cross bred dairy cows. The average dry matter content of the TMR prepared by Antaya *et al*. (2015) to conduct experiments in early lactation Jersey cows by supplementing them with incremental amounts of *Ascophyllum nodosum* (ANOD) meal was 60 per cent. Silva *et al*. (2015) prepared a grass based TMR having 60 per cent DM for studying the rumen fermentation and haematological parameters of sheep. Therefore, the DM content of the TMRs used in the present study are comparable to those of the above works.

On perusal of the data on DMI as a per cent of the body weight, given in Table 9, it could be seen that cows in groups, T1 and T2, consumed 3.76 and 3.25 kg DM, on an average, which was lower than the ICAR specification of 4.23 per cent. The DMI per day varied from 14.76 to 15.76 kg in cows of group T1 and from 12.79 to 14.09 in T2, which was also lower than the expected 16.92 kg DM, worked out on the basis of ICAR (2013), as given above. The CP intake worked out from the actual

daily DMI given above and the actual CP content given in Table 6, ranged from 2.25 to 2.40 and 1.90 to 2.10 kg, respectively, for cows in groups T1 and T2, respectively, which were higher than the calculated CP intake, as per ICAR (2013), of 1.88 kg, given above. The TDN intake worked out from the actual daily DMI given above and the calculated value of TDN given in Table 3, worked out to 9.68 to 10.33 and 8.39 to 9.24 kg, respectively, for cows in groups T1 and T2, respectively, which were higher than the calculated TDN intake, of 8.22 kg, calculated as per ICAR (2013) recommendations. This indicates that, the two experimental complete rations contained adequate nutrient density, which in turn ensured adequate CP and TDN intake, commensurate with the ICAR (2013), requirements.

5.2.2. Influence on production parameters

5.2.2.1. Body weight

The data on body weight of cows fed on the experimental rations, at fortnightly intervals are shown in Table 7. The data reveal that the average body weight of cows were 391.22 and 389.47 kg, at the start of the experiment, for those given rations, T1 and T2, respectively. On study of the data, it could be found that the body weight of cows fed on the two experimental rations in all the fortnights were similar ($P>0.05$). The body weight of animals increased in both the groups, from the beginning till the end of the experiment, with the final body weight being 423.69 and 433.50 kg for cows in group T1 and T2, respectively.

These results indicated that cows fed on both the experimental rations consumed enough energy to meet their nutrient requirement and extra nutrients were stored as body reserve showing that both rations were adequate and this was similar to the previous works of Raseel (2018) who observed positive energy balance in dairy cows fed on a complete feed containing 1/3rd pineapple waste instead of maize in the conventional complete ration and Chacko *et al*. (2020) who also observed a state of positive energy balance in lactating dairy cows fed on complete feeds containing three different levels of NDF, ranging from 25 to 35 per cent.

The final body weights observed in the present study are slightly lower, but the findings of this study are in concordance to those of Giridhar and Balaraman (2005) who observed an average body weight of 453.40 kg in cross bred dairy cows fed on berseem based TMRs containing three different levels of protein and energy, with the values being similar, across treatments. The body weight of the present investigation are higher, but the findings are in agreement to those of Raseel (2018) who reported values of 373.62 and 388.62 kg, respectively, in early lactation dairy cows fed on a conventional complete ration containing maize and another complete feed containing 1/3rd pineapple waste instead of maize in the conventional ration, with the values being similar.

Similarity in body weight of cows between the two experimental groups, as observed in the present study are also in agreement with the previous works of Lade (2007) who found that the body weight of dairy cows fed on an oats and berseem based complete feed and a complete feed, without green fodder, were similar; Kennedy *et al*. (2015) who observed that there was no significant difference in body weight of early lactating cows fed on citrus pulp based complete rations and a conventional grass concentrate feed and Scharen *et al.* (2015) who found that the body weight of lactating dairy cows fed on fodder maize based complete feed was similar to that of those fed on a conventional grass concentrate system.

The body weights are higher and the findings, except NEB, mentioned above are contradictory to that of Chacko *et al*. (2020) who obtained average body weight values of 336.67, 338.33 and 357.00 kg in cows fed on complete feeds containing 25, 30 and 35 per cent NDF, respectively, with cows in the 35 per cent NDF fed group having a significantly higher body weight than those fed on complete feeds with lower levels of NDF.

5.2.2.2. Dry matter intake (DMI)

5.2.2.2.1. DMI per day

The data on average daily DMI of cows fed on the rations are presented in Table 8. On study of the data, it could be found that there was significant difference ($P<0.05$) between the cows fed on both the experimental diets in all the six fortnights and significantly higher DMI was seen in cows fed on experimental ration T1 than those of T2, with the values being 15.66 and 13.98 kg, respectively.

The above values of average daily DMI of cows of were higher than that of Lade *et al*. (2007) who reported daily DMI values of 11.38, 10.59 kg, respectively, in cross bred dairy cows fed on an oats and berseem based complete feed and Purushothaman (2018) who got statistically similar values of 6.97 and 5.92 kg in cross bred cows fed on complete rations containing dhanwantharam thailam residue and rapeseed cake at five per cent level, respectively.

The findings of Chacko (2015) who got average daily DMI of 13.93, 14.36 and 14.64 kg in lactating dairy cows fed on complete feeds with 25, 30 and 35 per cent NDF, respectively and Raseel (2018) who recorded values of 15.24 and 15.27 kg, respectively in cows fed on complete rations in which 1/3rd of the energy source maize in the complete ration was replaced by pineapple waste are comparable to those of the present study.

The DMI values in the present investigation were lower than those of Scharen (2015) who reported values of 17.40 and 16.20 kg, respectively in lactating dairy cows fed on fodder maize based a complete feed and a conventional grass-concentrate system, without fodder maize.

The significantly higher DMI of cows fed on experimental ration T1 are in agreement with the works of Lade *et al*. (2007) who reported significantly higher DMI in cross bred dairy cows fed on an oats and berseem based complete feed, with green fodder, as compared to those fed on a complete feed, without green fodder; Kennedy *et al*. (2015) who observed significantly higher DMI in lactating dairy cows fed on complete feeds containing citrus pulp, as against those fed on an unsupplemented control and Scharen (2015) who reported significantly higher DMI

in lactating dairy cows fed on fodder maize based complete feed as against those fed on a conventional grass-concentrate system

Findings of similar daily DMI between groups, as reported by Chacko (2015), Purushothaman (2018) and Raseel (2018) in researches carried out in lactating dairy cows fed on complete feeds, mentioned above, are in contrast to the findings of the present study.

5.2.2.2.2. DMI per 100 kg body weight

Fortnightly data on DMI per 100 kg body weight are given in Table 9. The average daily DMI per 100 kg body weight of cows fed on the two experimental feeds; T1 and T2 were 3.76 and 3.25 kg, respectively. Analysis of the data revealed that cows fed on T1 had a significantly higher ($P<0.05$) DMI per 100 kg body weight, in contrast to those fed on T2.

The values of DMI per 100 kg body weight in both groups of the present study are higher, but the findings are in agreement with those of Lade *et al*. (2007), who reported that cross bred dairy cows fed on an oats and berseem based complete feed containing green fodder had a significantly higher DMI than those fed on a complete feed, without green fodder, with the values being 3.04 and 2.71 kg, respectively.

The DMI per 100 kg body weight of cows fed on ration T1 in this experiment were comparable while that of T2 was lower than those of Girdhar and Balaraman (2005) who reported an average value of 3.74 kg in cross bred dairy cows fed on berseem based TMRs containing three different levels of protein and energy and Chacko (2015) who recorded values of 3.71, 4.01 and 3.84 kg, in lactating dairy cows fed on complete feeds with NDF levels of 25, 30 and 35 per cent, respectively. The figures of 3.87 and 4.04 kg reported by Raseel (2018) who observed that cows fed on a conventional complete ration and another in which $1/3^{rd}$ of the energy source maize in the conventional ration was replaced by pineapple waste, were similar, are analogous to that of the present study. However, similarity in DMI per 100 kg body

weight, between treatments, as observed by the above three researchers are in contrast to the significant findings, observed in the present study.

5.2.2.2.3. DMI per metabolic body weight

The data on DMI per kg metabolic body weight shown in Table 9 reveal that the average DMI per kg metabolic body weight of cows fed on the two rations T1 and T2 were 0.17 and 0.15 kg, respectively. Analysis of the data revealed that cows fed on ration T1 had a significantly higher ($P<0.05$) DMI per kg metabolic body weight than those fed on T2.

The values of DMI per kg metabolic body weight in both groups of the present study are higher, but the findings are in agreement with those of Lade *et al*. (2007), who reported that cross bred dairy cows fed on an oats and berseem based complete feed containing green fodder had a significantly higher DMI than those fed on a complete feed, without green fodder, with the values being 0.13 and 0.12 kg, respectively.

The DMI per kg metabolic body weight of cows fed on ration T1 in this experiment were comparable while that of T2 was lower than those of Chacko (2015) who obtained DMI ranging from 0.16 to 0.17 kg in early lactating dairy cows fed on complete feeds with varying NDF levels. The DMI figures of 0.17 and 0.18 kg observed by Raseel (2018) in animals fed with a conventional complete ration and another in which $1/3^{rd}$ of the energy source maize in the conventional ration was replaced by pineapple waste, are akin to those of the present study. However, similarity in DMI per kg metabolic body weight, between treatments, as observed by the above two workers is in contrast to the significant findings, observed in the present study.

5.2.2.3. Milk yield

The data on milk yield of cows fed on the experimental rations, at fortnightly intervals are shown in Table 10. The data reveal that the initial and final milk yield of cows fed on experimental rations, T1 and T2 were 17.97 and 18.03 kg; 17.45 and

14.87 kg, respectively. On examination of the data, it could be seen that the milk yield of cows fed on experimental ration T1 started increasing from the first fortnight onwards, attaining the peak milk yield in the second fortnight and remained in the peak till the fourth fortnight while the milk yield of animals in T2 gradually decreased up to fourth fortnight, increased in the fifth fortnight, but immediately started declining again in the sixth fortnight, indicating that cows fed on ration T1 reached peak milk yield early and had greater persistency of milk yield than those in T2.

Even though there was no significant difference ($P>0.05$), the average daily milk yield of cows in group T2 was numerically lower by 2.58 kg (17.35 per cent), as compared to those in group T1.

The values of milk yield obtained in the present study are higher, with the findings being comparable to those of Lade *et al*. (2007) who observed that the average daily milk yield of cross bred dairy cows fed on a oats and berseem based complete feed and another complete feed, without green fodder were 9.15 and 8.43 kg per day, respectively, with the values being similar and Chacko *et al*. (2016) whose average daily milk yield ranged from 11.08 to 12.09 kg, in early lactating cows fed on complete feeds with varying levels of NDF. The values are higher but the findings are contradictory to that of Raseel (2018) who reported that lactating dairy cows fed on a complete feed containing $1/3^{rd}$ pineapple waste instead of maize had a significantly higher milk yield than those fed on a conventional complete ration consisting of maize alone, the yields being 12.94 and 11.94 kg, respectively.

Similarity in milk yield between treatments, with numerically lower milk yield in cows fed on T2 with coffee husk as compared to those in T1, without coffee husk, is in perfect agreement with the findings of Antaya *et al*. (2015) who reported that early lactation Jersey cows fed on a TMR supplemented with incremental amounts of *Ascophyllum nodosum* (ANOD) meal, a protein rich macroalga species,

had a similar milk yield, but the yield decreased numerically with increase in level of ANOD supplementation.

Tavarez *et al*. (2005) reported that replacement of corn with coffee hulls at 25 per cent level in TMR of Holstein-Zebu cows resulted in a significant decrease in milk production. A similar decline in milk yield, even though, statistically non significant, was observed in the present investigation also.

5.2.2.4. Milk composition

The data on fortnightly milk composition of cows fed on the two experimental rations are discussed below:

5.2.2.4.1. Milk fat

The average milk fat content of cows fed on the experimental rations, T1 and T2, at fortnightly intervals, given in Table 11, were 4.12 and 4.34 g per cent, respectively. Analysis of data on fat percentage revealed that there was no significant difference ($P>0.05$) between treatments in milk fat levels in any of the fortnights. The values of fat percentage obtained in this study are in the normal range of lactating dairy cows.

The milk fat values in present study are comparable and the similarity between groups are in accordance to those of Lade *et al*. (2007) who reported that the milk fat content of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a complete feed, without green fodder, the values being 4.84 and 4.69 g per cent, respectively; Chacko (2015) who found that early lactation dairy cows fed on complete rations with 25, 30 and 35 per cent of NDF had a similar milk fat content of 4.60, 4.62 and 4.51 g per cent, respectively and Raseel (2018) who observed that the fat content of dairy cows fed on a complete feed containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 3.97 and 4.20 per cent, respectively.

Similarity in milk fat content observed in the present investigation are also in agreement with the previous works of Hundal *et al.* (2004) who observed that

lactating dairy cows fed on complete feeds containing berseem and oat hay had a similar fat content and Kennedy *et al*. (2015) who observed that the milk fat content of lactating dairy cows fed on a complete feed containing 19 per cent citrus pulp was similar to those fed on conventional-grass concentrate system.

Contrasting result by way of a significantly higher milk fat content was reported by Wanapat *et al.* (2000) who reported that lactating Holstein Friesian cross bred cows fed on a cassava hay based complete ration at the rate of 1.70 kg per head per day had a significantly higher milk fat than those fed on unsupplemented control ration.

5.2.2.4.2. Total solids

The average total solids (TS) content of milk from cows fed on the experimental rations, T1 and T2, at fortnightly intervals, given in Table 12, were 12.45 and 12.39 g per cent, respectively. Analysis of the data on TS percentage showed that the TS levels were similar ($P>0.05$) and within the standard range of milking cows.

The TS values in present study are lower, but the similarity between groups are in accordance to those of Lade *et al*. (2007) who observed that the TS values of cross bred dairy cows fed on an oats and berseem based complete feed, with green fodder, were similar to those fed on a complete feed, without green fodder, the values being 14.57 and 14.04 g per cent, respectively, Chacko (2015) who found that early lactation dairy cows fed on complete rations with 25, 30 and 35 per cent of NDF had a similar TS content, the values being, 13.01, 13.06 and 13.14 g per cent, respectively and Raseel (2018) who observed that the TS content of dairy cows fed on a complete feed containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 14.72 and 14.39 per cent, respectively.

Similarity in TS content observed in the present investigation are also in agreement with the previous works of Delany *et al*. (2010) who observed that lactating dairy cows fed on a TMR alone and a pasture plus grain diet, had similar TS

and Kennedy *et al*. (2015) who observed that the TS content of lactating dairy cows fed on a complete feed containing 19 per cent citrus pulp was similar to those fed on conventional-grass concentrate system.

Contrasting result by way of a significantly lower TS content was reported by Gulati (2017) who reported that the TS content of cows fed on a TMR containing fodder maize as roughage source without grazing were significantly lower than those sent for outdoor grazing.

5.2.2.4.3. Solids not fat

The average solid not fat (SNF) content of cows fed on the experimental rations, T1 and T2, at fortnightly intervals, given in Table 13, were 8.63 and 8.53 g per cent, respectively. Analysis of data on SNF percentage revealed that there was no significant difference ($P>0.05$) between treatments in SNF levels in any of the fortnights. The values of SNF percentage obtained in this study are in the normal range of lactating dairy cows.

The values as well as the findings of Chacko (2015) who found that early lactation dairy cows fed on complete rations with 25, 30 and 35 per cent of NDF had a similar SNF content of 8.45, 8.44 and 8.51 g per cent, respectively, are in agreement with the results of the present investigation.

The SNF values in present study are lower, but the similarity between groups are in accordance to those of Lade *et al*. (2007) who observed that the SNF values of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a complete feed, without green fodder, the values being 9.73 and 9.35 g per cent, respectively and Raseel (2018) who observed that the SNF content of dairy cows fed on a complete feed containing $1/3^{rd}$ pineapple waste instead of maize in the conventional ration were similar, the values being 10.75 and 10.17 per cent, respectively.

The findings of Hundal *et al.* (2004) who observed that lactating dairy cows fed on complete feeds containing berseem and oat hay had a similar SNF content;

Delaney *et al*. (2010) who reported similar SNF content in lactating dairy cows fed on various TMRs and Kennedy *et al*. (2015) who observed that the SNF content of lactating dairy cows fed on a complete feed containing 19 per cent citrus pulp was similar to those fed on conventional-grass concentrate system, tend to be in agreement with those of the present experiment.

5.2.2.4.4. Milk protein

The average milk protein content of cows fed on the experimental rations, T1 and T2, at fortnightly intervals, given in Table 14, were 4.12 and 4.34 g per cent, respectively. Analysis of data on milk protein percentage revealed that there was no significant difference (P>0.05) between treatments in milk protein levels in any of the fortnights. The values of milk protein percentage obtained in this study are in the normal range of lactating dairy cows.

The milk protein values in present study are higher, but the similarity between groups are in accordance to those of Lade *et al*. (2007) who reported that the milk protein content of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a complete feed, without green fodder, the values being 3.58 and 3.54 g per cent, respectively; Chacko (2015) who found that early lactation dairy cows fed on complete rations with 25, 30 and 35 per cent of NDF had a similar milk protein content of 2.80, 2.92 and 2.93 g per cent, respectively and Raseel (2018) who observed that the milk protein content of dairy cows fed on a complete feed containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 2.85 and 3.07 per cent, respectively.

Similarity in milk protein content observed in the present investigation are also in agreement with the previous works of Hundal *et al.* (2004) who observed that lactating dairy cows fed on complete feeds containing berseem and oat hay had a similar milk protein content; Delany *et al*. (2010) who observed that the milk protein of lactating dairy cows fed on a complete ration alone and a pasture plus grain diet were similar; Ortega *et al*. (2014) who observed that the milk protein content of

lactating dairy cows fed on a complete ration containing fodder maize as roughage source at 34.90 per cent level without grazing was similar to those sent for daily grazing and Kennedy *et al*. (2015) who reported that the milk protein levels of lactating dairy cows fed on a complete feed containing 19 per cent citrus pulp was similar to those fed on conventional-grass concentrate system.

A contrasting result by way of a significantly lower milk protein content was reported by Gulati (2017) who reported that the milk protein content of cows fed on a TMR containing fodder maize as roughage source without grazing were significantly lower than those sent for outdoor grazing.

5.2.2.4.5. Milk urea nitrogen

The average milk urea nitrogen (MUN) content of cows fed on the experimental rations, T1 and T2, at fortnightly intervals, given in Table 15, was 9.57 and 9.43 g per cent, respectively. Analysis of the data on MUN percentage revealed that there was no significant difference ($P>0.05$) between treatments in MUN levels in any of the fortnights. The values of MUN percentage obtained in this study are in the normal range of lactating dairy cows.

The MUN values in present study are lower, but the similarity between groups are in accordance to those of Raseel (2018) who observed that the MUN content of dairy cows fed on a complete feed containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 12.11 and 12.10 mg per cent, respectively.

A contrasting result by way of a significantly higher MUN content was put forth by Kelzer *et al.* (2009) who reported that early lactating Holstein cows fed on TMRs incorporated with dried distiller's grains plus solubles at 15 per cent level had a significantly higher MUN content than those fed on zero per cent level.

Contradictory findings in the form of a significantly lower MUN content was reported by Chacko (2015) who reported that the MUN content of lactating dairy cows fed on complete rations with 25, 30 and 35 per cent of NDF, were 12.50, 10.40,

9.35 mg per cent, with the MUN value in the 35 per cent NDF fed group being significantly lower than the other two groups, containing less of NDF.

5.2.2.5. Total yield of four per cent fat corrected milk, milk fat and protein

5.2.2.5.1. Four per cent fat corrected milk yield

The data on total yield of four per cent fat corrected milk (FCM) in the experiment are given in Table 17, the values being 9790.45 and 8207.87 kg, respectively for cows in groups T1 and T2. The fortnightly average FCM per group, given in the above Table indicate that cows in T1 had a significantly higher ($P<0.01$) FCM yield than those in T2, with the values being 1631.74 and 1367.98 kg for cows in groups T1 and T2, respectively. The average FCM per cow per day, given in the same Table indicate that the values ranged from 17.76 to 20.22 and 15.63 to 17.98 kg, in cows of groups T1 and T2, respectively.

The values of total yield of FCM yield observed in the present study are higher, but the findings are in agreement to that reported by Khan *et al*. (2010) who observed that early lactation dairy cows fed on a complete rations had a significantly higher FCM yield than those fed on two different conventional systems, with wheat straw plus concentrate mixture in mash form and pellet form, respectively, both fed separately, with the values being in the range of 4320.00 to 4935.60 kg and Chacko (2015) who found that early lactation dairy cows fed on complete rations with NDF levels of 25 (T1) , 30 (T2) and 35 (T3) per cent had total FCM yields of 6187.92, 6888.12 and 6853.75 kg, respectively, with the high NDF groups, viz., T2 and T3 having a significantly higher FCM yield than those in T1, with T2 and T3 being similar.

The values of average FCM per cow per day obtained in this study are higher than the values of 9.94 and 9.65 kg reported by Lade *et al*. (2007) who found that the average daily FCM yield of cross bred dairy cows fed on an oats and berseem based complete feed were similar to those fed on a complete feed, without green fodder, with their findings being contradictory to those of the present study.

5.2.2.5.2. Milk fat yield

The data on total milk fat yield in the experiment given in Table 19 indicate that the values were 402.65 and 338.62 kg for cows in groups T1 and T2, respectively. The fortnightly average milk fat yield per group, given in the above Table indicate that cows in T1 had a significantly higher (P<0.01) fat yield than those in T2, with the values being 67.11 and 56.44 kg for cows in groups T1 and T2, respectively. The average daily milk fat yield per cow, given in the same Table indicate that the values ranged from 0.72 to 0.84 and 0.60 to 0.75 kg, in cows of groups T1 and T2, respectively.

The values of total milk fat yield observed in the present study are higher, but the findings are in agreement to that reported by Chacko (2015) who found that early lactation dairy cows fed on complete rations with NDF levels of 25 (T1) , 30 (T2) and 35 (T3) per cent had total milk fat yields of 256.22, 288.88 and 287.19 kg, respectively, with the high NDF groups, viz., T2 and T3 having a significantly higher fat yield than those in T1, with T2 and T3 being similar.

5.2.2.5.3. Milk protein yield

The data on total milk protein yield in the experiment given in Table 20 indicate that the values were 294.29 and 242.19 kg for cows in groups T1 and T2, respectively. The fortnightly average milk protein yield per group, given in the above Table indicate that cows in T1 had a significantly higher (P<0.01) protein yield than those in T2, with the values being 49.05 and 40.37 kg, for cows in groups T1 and T2, respectively. The average daily milk protein yield per cow, given in the same Table indicate that the values ranged from 0.55 to 0.61 and 0.46 to 0.51 kg, in cows of groups T1 and T2, respectively.

The values of total milk protein yield observed in the present study are higher, but the findings are in agreement to that reported by Chacko (2015) who found that early lactation dairy cows fed on complete rations with NDF levels of 25 (T1), 30 (T2) and 35 (T3) per cent had total milk protein yields of 164.41, 183.79 and 184.87

kg, respectively, with the high NDF groups, viz., T2 and T3 having a significantly higher protein yield than those in T1, with T2 and T3 being similar.

5.2.2.6. Incidence of off flavours in milk

The data given in Table 16 reveal that there was no incidence of any off flavour in milk from cows maintained on the two rations in the entire experimental period, which tend to agree with the findings of Choi *et al.* (2019) who reported that incorporation of fermented spent instant coffee grounds, at 10 per cent level on DM basis, in TMR for lactating dairy cows did not show any off flavor in milk.

These observations however, tend to be in contrast to those of Bartsch and Wickes (1979) who found that milk from cows fed 3.40 kg of citrus meal in their ration, was abnormal in flavour compared with milk from cows fed no citrus meal.

5.2.2.7. Blood parameters

The data presented in Table 20 indicate the values of glucose and BUN.

5.2.2.7.1. Glucose

The initial and final plasma glucose levels of cows fed on complete feeds T1 and T2 were 51.01, 49.22 and 52.04, 50.13 mg per 100 ml, respectively, with the values being similar ($P>0.05$) and falling within the normal level of milking cows.

The blood glucose levels obtained in this study are lower, but the findings are in agreement to those of Chacko *et al*. (2017a) who reported that early lactating dairy cows fed on complete feeds with 25, 30 and 35 per cent NDF, had similar blood glucose, the values being 66.11, 66.10, 65.94 mg per 100 ml, respectively and Raseel (2018) who found that the blood glucose levels of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 62.67 and 65.17 mg per 100 ml, respectively.

Similarity in blood glucose levels between treatments, as observed in this study are also in agreement with the previous works of Purushothaman (2018) who reported that the blood glucose levels of cross bred cows fed on complete feeds containing dhanwantharam thailam residue and rape seed cake at five per cent level

were similar and Nha and Pattarajinda (2019) who observed that the blood glucose values of lactating dairy cows fed on complete feeds with 20 and 25 per cent NDF were similar.

5.2.2.7.2. Blood urea nitrogen

The initial and final BUN values of cows fed on complete feeds T1 and T2 were 16.86, 16.95 and 23.17, 24.36 mg per 100 ml, respectively, with the values being similar (P>0.05) and normal in case of milking cows.

The BUN levels obtained in this study are higher, but the findings tend to agree with those of Chacko *et al*. (2017a) who got statistically similar figures of 7.82, 8.49 and 8.64 mg per 100 ml, in early lactating dairy cows fed on complete rations with 25, 30 and 35 per cent NDF, respectively and Raseel (2018) who found that the BUN levels of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 12.75 and 12.71 mg per 100 ml, respectively.

Similarity in BUN levels between treatments, as observed in this study are also in agreement with the previous works of Purushothaman (2018) who reported that the BUN content of cross bred cows fed on complete feeds containing dhanwantharam thailam residue and rape seed cake at five per cent level, were similar and Nha and Pattarajinda (2019) who observed that the BUN content of lactating dairy cows fed on complete rations with 20 and 25 per cent NDF, were similar.

Contradictory results by the form of significantly higher BUN level were reported by Hundal *et al.* (2004) who reported significantly higher BUN value in lactating dairy cows fed on complete feeds containing berseem and oat hay, as compared to those fed on a conventional hay-concentrate feed.

5.2.2.8. Mineral parameters

The data on values of plasma mineral parameters are given in Table 21.

5.2.2.8.1. Calcium

The initial and final calcium (Ca) content of cows fed on complete feeds T1 and T2 were 8.75, 8.54 and 9.00, 9.25 mg per 100 ml, respectively, with the values being similar (P>0.05) and within the normal level of milking cows.

Chacko *et al*. (2017a) reported values ranging from 8.15 to 9.87 mg per 100 ml in lactating dairy cows fed on complete feeds with varying levels of NDF, which are analogous to those of the present study. These values are slightly lower, but the findings are comparable to Purushothaman (2018) who reported that the plasma Ca content of cross bred cows fed on complete feeds containing dhanwantharam thailam residue and rape seed cake at five per cent level were similar, the values being 9.76 and 10.68 mg per 100 ml, respectively and Raseel (2018) who reported statistically similar values of 10.50 and 11.00 mg per 100 ml, respectively, in cows fed on a conventional complete feed and another complete feed containing pineapple waste, instead of maize.

5.2.2.8.2. Phosphorus

The initial and final phosphorus (P) content of cows fed on complete feeds T1 and T2 were 6.60, 6.26 and 6.34, 6.16 mg per 100 ml, respectively, with the values being similar (P>0.05) and within the normal range of dairy cows.

The findings of Chacko *et al*. (2017a) who reported statistically similar values ranging from 5.37 to 5.69 mg per 100 ml in early lactation dairy cows fed on complete feeds with varying levels of NDF are similar to those of this experiment. These values are slightly lower, but the findings are comparable to Raseel (2018) who reported statistically similar values of 6.56 and 6.57 mg per 100 ml, in cows fed on complete feeds containing maize and pineapple waste, respectively.

Contrasting results by the way of a higher P value was reported by Purushothaman (2018) who observed significantly higher P value in cows fed on complete rations containing dhanwantharam thailam residue than those fed on complete rations containing rape seed cake at five per cent level.

5.2.2.9. Digestibility coefficients of nutrients

The data on digestibility coefficients of nutrients are given in Table 23.

5.2.2.9.1. Dry matter

The digestibility coefficient of dry matter (DM) was 65.33 and 50.78 per cent in animals maintained on the dietary treatments, T1 and T2, respectively, with T2 being significantly lower ($P<0.05$) than T1.

The significantly lower digestibility coefficient of DM observed in this study is in partial agreement with the findings of Badarinaa *et al*. (2013) who performed an *in vitro* experiment by adding fermented coffee husk at levels of 0, 10, 20, 30 and 40 per cent in Napier grass based TMR having a total CP of 13.0 to 13.42 per cent and TDN of 61 to 65 per cent and reported that the dry matter digestibility significantly decreased with increase in level of incorporation above 20 per cent; with the values being 66.80, 59.19, 56.22, 52.21 and 47.51 per cent, for the 0, 10, 20, 30 and 40 per cent coffee husk incorporated groups, respectively; with the DM digestibility being significantly lower at 30 and 40 per cent level of incorporation as compared to the lower levels. These results also showed that the values of group T1 of the present study are comparable to those of the first three groups while that of T2 are comparable to the last two groups of Badarinaa *et al*. (2013).

The values of digestibility coefficient of DM obtained in group T1 of the present experiment are comparable while that of group T2 are lower than the values of 63.12 and 70.59 per cent, respectively, observed by Lade *et al*. (2007) who observed that the digestibility coefficients of DM of cross bred dairy cows fed on an oats and berseem based complete rations were similar to those fed on a complete feed, without green fodder. However, similarity in digestible DM observed by those workers are in contrast to the significantly lower DM digestibility observed in the coffee husk fed, group T2 as compared to the unsupplemented group T1, in this study.

Chacko (2015) reported statistically similar digestible DM values of 60.33, 59.83 and 58.60 per cent in early lactating dairy cows fed on complete rations with

25, 30 and 35 per cent NDF, respectively; which are lower than that of group T1 of the present study. The DM digestibility in T1 is however, lower than that of Raseel (2018) who found that the DM digestibility of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 78.18 and 79.30 per cent, respectively. The DM digestibility value of T1 are comparable to Purushothaman (2018) who reported that the DM digestibility of cross bred cows fed on complete feeds containing dhanwantharam thailam residue and rape seed cake at five per cent level were similar, the values being 68.53 and 68.60 per cent, respectively. The DM digestibility of cows in group T2, obtained in the present study was lower than that reported by all the above workers. The significantly lower DM digestibility observed in cows of T2 as compared to those fed on T1, are in contrast to the findings of the above three researchers.

The significantly lower results obtained in the treatment group (T2) in the present study, showed a similar trend as that of Maulfair *et al.* (2011) who observed a significantly lower digestibility coefficient of DM in lactating cows fed on TMR with large particle size, as compared to those fed on a TMR with small particle size.

Contradictory tendencies in the form of significantly higher digestibility coefficient of DM were reported by Xu *et al*. (2008) who observed that substitution of wet brewer's grains, which formed 30 per cent of TMR for wethers, with wet barley tea grounds at 5, 10 and 15 per cent levels, significantly increased the digestibility coefficient of DM.

5.2.2.9.2. Organic matter

The digestibility coefficient of organic matter (OM) was 70.61 and 58.75 per cent in T1 and T2, respectively, with T2 being significantly lower ($P<0.05$) than T1.

Lade *et al*. (2007) reported similar OM digestibility coefficient values of 63.72 and 70.53 per cent in early lactating dairy cows fed on oats based complete feeds with and without berseem as the roughage, respectively. Even though the OM

digestibility values of T1 of the present study was comparable and T2 was lower than those of Lade *et al*. (2007), similarity in digestible OM observed in that study is in contrast to the results of the present investigation.

The values observed in group T1 of the present study are higher while that of group T2 are lower than those of Chacko (2015) who reported that the digestibility coefficients of OM of early lactation dairy cows fed on complete rations with 25, 30 and 35 per cent NDF, were similar, which are contradictory to the present experiment, with the values being 68.53, 68.13 and 67.09 per cent, respectively.

The values of both the treatment groups in this study were lower than that of Raseel (2018) who found that the OM digestibility of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 79.74 and 81.64 per cent, respectively, which are also in contrast to the present results.

The findings of Susanti *et al*. (2015) who reported that goats fed on TMRs to which Ramie waste a, fibre rich plant, was added, instead of 20 per cent soyabean meal, had a significantly lower digestibility coefficient of OM than those fed on the unsupplemented control, are in agreement with the results of the present investigation.

The findings of Girdhar and Balaraman (2005) who observed that cross bred dairy cows fed on berseem based TMRs containing three different levels of protein, energy and fodder had a similar digestibility coefficient of OM; tend to be in contrast with those of the present study.

5.2.2.9.3. Crude protein

The digestibility coefficient of crude protein (CP) values of cows fed on dietary treatments T1 and T2 were 69.85 and 58.77 per cent, respectively with T2 being significantly lower ($P<0.05$) than T1.

The value of digestibility coefficient of CP obtained in group T1 of the present study are higher than both groups, while those in T2 are comparable to the

green fodder containing first group of Lade *et al*. (2007) who reported a values of 57.97 and 63.92 per cent in cows fed on an oats based complete feed containing the green fodder, berseem (T1) and another without green fodder (T2), respectively, with T1 being significantly lower than T2; which is contrary to the findings of the present investigation, where, group T2, the 20 per cent coffee husk added group containing less of green fodder (20 %) had a significantly lower CP digestibility than group T1, which contained more green fodder (27.50 %).

Chacko (2015) found that the CP digestibility of early lactating cows fed on complete feeds with 25, 30 and 35 per cent NDF, were similar, the values being 47.72, 48.31 and 48.60 per cent, respectively, which are lower than that of the present investigation. The values observed in the present study are however, lower than that of Raseel (2018) who found that the CP digestibility of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 73.53, and 74.63 per cent, respectively. Similarity in CP digestibility, between treatments, observed by both these workers is in contrast to the results of the present investigation.

Xu *et al*. (2008) observed that substitution of wet brewer's grains, which formed 30 per cent of TMR for wethers, with wet barley tea grounds at 5, 10 and 15 per cent levels, significantly decreased the digestibility coefficient of CP, which are in agreement with the findings of the present study. The findings of this investigation are also in agreement with those of Antaya *et al*. (2015) who reported that early lactation Jersey cows supplemented with incremental amounts of *Ascophyllum nodosum* (ANOD) meal, a macroalga species and a protein supplement having 20 per cent CP, in TMR having an average dry matter content of 60 per cent, resulted in a significant reduction in CP digestibility, with increase in the level of ANOD, in TMR.

The observations of Girdhar and Balaraman (2005) who found that cross bred dairy cows fed on berseem based TMRs containing three different levels of protein (10, 12, 14 % CP) and energy (55, 60, 65 % TDN), with incremental increase in the

levels of the green fodder berseem, viz., 25, 34 and 40 per cent, respectively, resulted in a significantly higher digestibility coefficient of CP, with increase in the level of CP, TDN and green fodder, are in contrast to the results of the present study.

Hundal *et al*. (2004) found that the CP digestibility of lactating dairy cows fed on berseem and oat hay based complete feeds, as well as a conventional ration were similar, which are contradictory to the findings of the present investigation.

5.2.2.9.4. Ether extract

The digestibility coefficient of ether extract (EE) of T1 and T2 were 97.12 and 95.80 per cent, respectively, with T2 being significantly lower ($P<0.05$) than T1.

Lade *et al*. (2007) reported that cows fed on an oats based complete feed containing the green fodder, berseem had a significantly lower digestibility coefficient of EE than those fed on a complete feed, without green fodder, with the values being 87.49 and 91.19 per cent, respectively. The EE digestibility of Lade *et al*. (2007) are lower than that of the present study and their findings are in contrast to those of the present experiment.

Chacko (2015) observed that early lactating cows fed on complete rations with NDF levels ranging from 25 to 35 per cent, gave similar digestible EE values, in the range of 82.21 to 86.38 per cent. Raseel (2018) reported that the digestibility coefficient of EE of early lactation dairy cows fed on complete rations containing $1/3^{rd}$ pineapple waste instead of maize in the conventional complete ration were similar, the values being 63.90 and 68.07 per cent, respectively. Even though the EE digestibility values of both these workers were lower than that of the present study, their findings tend to disagree with those of the present investigation.

The significantly lower digestibility coefficient of EE obtained in group T2 in this study, in comparison to group T1, are in accordance with the previous work of Xu *et al*. (2008) who observed that substitution of wet brewer's grains, which formed 30 per cent of TMR for wethers, with wet barley tea grounds at 5, 10 and 15 per cent levels, significantly decreased the digestibility coefficient of EE.

Girdhar and Balaraman (2005) observed that cross bred dairy cows fed on berseem based TMRs containing three different and incremental levels of protein, energy and fodder, had a similar digestibility coefficient of EE, which tend to be in contrast to the significant findings of the present study.

The findings of Purushothaman (2018) who observed that the digestibility coefficient of EE of crossbred cows fed on a complete feed containing dhanwantharam thailam residue at five per cent level were significantly higher than those fed on a control complete feed containing rape seed cake at five per cent level, also tend to disagree with the results of this study.

5.2.2.9.5. Crude fibre

The digestibility coefficient of crude fibre (CF) of cows fed on T1 and T2 were 54.75 and 35.33 per cent, respectively, with T2 being significantly lower ($P<0.05$) than T1.

Chacko (2015) reported similar CF digestibility in early lactating dairy cows fed on complete feeds having 25, 30 and 35 per cent NDF, the values being 46.10, 48.53 and 49.18 per cent, respectively. The values obtained in the present study are higher than Chacko (2015), but the findings are contradictory to those of him. The CF digestibility in group T1 of the present investigation was comparable, while group T2 was lower than that of Raseel (2018) who reported that the digestibility coefficient of CF of early lactation dairy cows fed on complete rations containing 1/3rd pineapple waste instead of maize in the conventional complete ration were similar, the values being 54.29 and 49.87 per cent, respectively; with the similar findings between treatments being contradictory to the results of the present study.

Girdhar and Balaraman (2005) found that cross bred dairy cows fed on berseem based TMRs containing three different and incremental levels of protein, energy and fodder had a significantly lower digestibility coefficient of CF, with increase in the level of CP, TDN and fodder levels in TMR, which tend to agree with the significantly lower CF digestibility in T2 as compared to T1, in this study. The

present findings are also in conformity to those of Purushothaman (2018) who found that crossbred cows fed on complete feed containing dhanwantharam thailam residue at five per cent level had a significantly lower digestibility coefficient of CF than those fed on complete feed containing rape seed cake at five per cent level.

The observations of Saijpaul *et al*. (2005) who found that lactating dairy cows fed on complete feeds containing green fodder as roughage source had significantly higher digestibility coefficient of CF than those fed on complete rations containing dry fodder as roughage source, shows a similar trend as that of this experiment where, group T1, which contained more green fodder (27.50 %) had a significantly higher CF digestibility than group T2, the coffee husk added group containing less of green fodder (20 %).

The findings of Susanti *et al*. (2015) who reported that goats fed on TMRs to which Ramie waste a, fibre rich plant, was added, instead of 20 per cent soyabean meal, had a numerically lower, but non-significant, digestibility coefficient of CF than those fed on the unsupplemented control, are in partial agreement with the results of the present investigation.

Lade *et al*. (2007) observed that the digestibility coefficients of CF of cross bred dairy cows fed on a berseem based complete feed were similar to those fed on a complete feed, without green fodder, the values being 52.12 and 59.83 per cent, respectively. The CF digestibility values of cows in group T1 of the present study are comparable to both the groups of Lade *et al*. (2007) while the values of group T2 of the present study are lower than that reported by these workers. However, the findings of similarity in CF digestibility observed in that study are in contrast to those of the present investigation.

5.2.2.9.6. Nitrogen free extract

The average digestibility coefficient of nitrogen free extract (NFE) of cows fed on T1 and T2 were 68.92 and 57.13 per cent, respectively, with T2 being significantly lower ($P<0.05$) than T1.

The value of digestibility coefficient of NFE in T1 was comparable, while that of T2 obtained in the present study are lower than that of Chacko (2015) who observed similar NFE digestibility in early lactating milch cows fed on complete rations having 25, 30 and 35 per cent NDF, the values being 46.10, 48.53 and 49.18 per cent, respectively and Raseel (2018) who reported that the digestibility coefficient of NFE of early lactation dairy cows fed on complete rations containing 1/3rd pineapple waste instead of maize in the conventional complete ration were similar, the values being 63.90 and 68.07 per cent, respectively. Similarity in NFE digestibility, between treatments, observed in both these studies are contrary to the significant findings observed in the present experiment.

The value of digestibility coefficient of NFE of groups T1 and T2, obtained in the present study are lower and the findings are contrary to that of Lade *et al*. (2007) who observed that the digestibility coefficient of NFE of cows fed on an oats based complete feed with the green fodder berseem, were significantly lower than those fed on complete feed without green fodder, the values being 87.49 and 91.18 per cent, respectively.

The findings of Purushothaman (2018) who reported that the digestibility coefficient of NFE of cows fed on complete feed containing dhanwantharam thailam residue at five per cent level were significantly lower than those fed on complete feed containing rape seed cake at five per cent level tends to agree with the results of the present study.

5.2.2.9.7. Neutral detergent fibre

The digestibility coefficient of neutral detergent fibre (NDF) of T1 and T2 were 64.35 and 51.37 per cent, respectively, with T2 being significantly lower ($P<0.05$) than T1.

The NDF digestibility of T1 in this investigation was higher, while that of T2 was lower than Chacko (2015) who identified similar NDF digestibility in cows fed on complete rations having 25, 30 and 35 per cent NDF, the values being 57.92,

58.10 and 59.89 per cent, respectively and Raseel (2018) who reported that the digestibility coefficient of NDF of early lactation dairy cows fed on complete rations containing 1/3rd pineapple waste instead of maize in the conventional complete ration were similar, the values being 56.94 and 57.85 per cent, respectively, both of which are contrary to the findings observed in the present investigation.

The significantly lower digestibility coefficient of NDF obtained in group T2 in this study are in accordance with the previous work of Xu *et al*. (2008) who observed that substitution of wet brewer's grains, which formed 30 per cent of TMR for wethers, with wet barley tea grounds at 5, 10 and 15 per cent levels, significantly decreased the digestibility coefficient of NDF; Susanti *et al*. (2015) who reported that the goats fed on Ramie waste added TMR had a significantly lower digestibility coefficient of NDF than those fed on the unsupplemented control and Sarkar *et al*. (2019) who found that lactating red Chittagong cows fed on a maize stover based TMR had a significantly lower digestibility coefficient of NDF than those fed on conventional grass-concentrate system.

Results in the form of a significantly higher digestibility coefficient of NDF in cows fed on complete rations containing more of green fodder, similar to ration T1; in comparison to those with less of green fodder, similar to ration T2; of the present study, which tend to agree with the present experiment, were reported by Hundal *et al*. (2004) who reported that lactating dairy cows fed on berseem and oat hay based complete feeds had significantly higher digestibility of NDF than those fed on a conventional grass concentrate ration and Kajla *et al*. (2019) who found that the digestibility coefficient of NDF of lactating dairy cows fed on wheat straw based TMRs were significantly higher than those fed on conventional feeds.

Contradictory findings in the form of similar digestibility coefficient of NDF was reported by Antaya *et al*. (2015) who observed that early lactation Jersey cows fed on TMRs supplemented with incremental amounts of ANOD meal, showed similar NDF digestibility.

5.2.2.9.8. Acid detergent fibre

The digestibility coefficient of acid detergent fibre (ADF) of cows fed on diets T1 and T2 were 64.76 and 50.33 per cent, respectively, with T2 being significantly lower ($P<0.05$) than T1.

The ADF digestibility of T1 in this experiment are greater, with T2 being analogous to Chacko (2015) who found that the digestibility coefficients of ADF of early lactation dairy cows fed on complete rations with 25 (T1), 30 (T2), and 35 (T3), per cent NDF, containing 14, 21 and 29 of the roughage, paddy straw, were 47.04, 51.22 and 54.44 per cent, respectively, with T2 and T3, which were similar among themselves as well as significantly superior to T1; which are in contrast to the findings of the present study where, group T1, which contained more of roughage in the form of green fodder (27.50 %) had a significantly higher ADF digestibility than group T2, the coffee husk added group containing less of green fodder (20 %). The ADF digestibility values of both the groups in this experiment are higher, but the findings are contrary to that of Raseel (2018) who reported that the digestibility coefficient of ADF of early lactation dairy cows fed on complete rations containing $1/3^{rd}$ pineapple waste, instead of maize in the conventional complete ration were similar, the values being 47.90 and 46.85 per cent, respectively.

The findings of Kajla *et al*. (2019) who found that the ADF digestibility of milch cows given wheat straw based TMRs, containing more of roughage, were significantly higher than those fed on conventional feeds, with less of roughage, tend to agree with the results of the present investigation where cows fed on ration T1, with no coffee husk and more of green fodder (27.50 %) had a superior digestibility coefficient of ADF than T2, with less of green fodder (20%).

The findings of Susanti *et al*. (2015) who reported that goats fed on TMRs to which Ramie waste a, fibre rich plant, was added, instead of 20 per cent soyabean meal, had a numerically lower, but non-significant, digestibility coefficient of ADF

than those fed on the unsupplemented control, are in partial agreement with the results of the present investigation.

Contrasting results in the form of similar digestibility coefficient of ADF was reported by Girdhar and Balaraman (2005) who observed that cross bred dairy cows fed on berseem based TMRs containing three different and incremental levels of protein, energy and green fodder had a similar digestibility coefficient of ADF.

5.2.2.10. Rumen fermentation parameters

The data on rumen fermentation parameters are given in Table 24.

5.2.2.10.1. pH

The average values of pH in cows maintained on the two experimental rations T1 and T2 were 6.72 and 6.77, respectively, with the values being similar ($P>0.05$) and falling within the normal range for cattle.

Even though the pH values are higher and hence better; the findings tend to agree with the observations of Chacko *et al*. (2017b) who reported that lactating dairy cows fed on complete rations with varying NDF levels viz., 25, 30 and 35 per cent had a similar rumen pH, the values being 6.10, 6.10 and 6.17, respectively and Raseel (2018) who found that the rumen pH of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the value being 6.30, for both the groups.

The findings of the present investigation are in conformity with those of Li *et al*. (2003) who reported that Holstein steers fed on complete feeds containing beet pulp at 4.80 per cent level and a conventional concentrate-roughage ration had similar rumen pH; Einarson *et al*. (2004) who reported that the pH of rumen liquor of lactating dairy cows fed on complete feeds with variable length of chopped barley silage were in the normal range and similar to those fed on a conventional grass-concentrate ration; Gupta *et al*. (2006) who observed that the rumen pH of cross bred male cattle fed on an berseem based complete ration, containing more of green fodder and a wheat straw based complete ration, without green fodder, were similar; Kelzer

et al. (2009) who observed similar pH in milking cows given complete rations containing corn milling co-products at zero and 15 per cent level; Badarinaa *et al*. (2013) who observed that the rumen pH of Napier grass based TMRs supplemented with fermented coffee husk at levels of 0, 10, 20, 30 and 40 per cent, were similar, Jeong *et al.* (2016) who observed that the pH of rumen liquor of Hanwoo steers fed on complete feeds with and without Korean rice wine residue were similar and Purushothaman (2018) who reported that the pH of cross bred cows fed on complete rations containing dhanwantharam thailam residue and rapeseed cake at five per cent level were similar.

5.2.2.8.10.2. Total volatile fatty acids

The average values of total volatile fatty acid (TVFA) in cows maintained on the dietary regimens T1 and T2 were 82.70 and 84.94 meq per l, respectively, with T2 having a significantly higher ($P<0.05$) TVFA than T1 and the values were in the normal range of 70 to 150 meq/ l as cited in Animal Nutrition by McDonald *et al*. (2002).

The TVFA values of this investigation are akin to Gupta *et al*. (2006) who found that the TVFA content of cross bred male cattle fed on a berseem based complete ration, were significantly higher than those fed on a wheat straw based complete ration, without green fodder; with the values 86.47, 80.61 mmol per l, respectively. These values are higher than the first and comparable to the second and third groups of Chacko *et al.* (2017b) who reported that the TVFA content of lactating dairy cows fed on complete rations with varying NDF levels viz., 25, 30 and 35 per cent, increased linearly and significantly with increase in the NDF content of the ration, the values being 73.71, 80.51 and 83.68 meq per 100 ml, respectively. The findings of both the above researchers are however contradictory to the findings of the present study. The TVFA values in this study are comparable, but the findings are in contrast to that of Raseel (2018) who found that the TVFA of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the

conventional ration were similar, the values being 82.20 and 82.04 meq per l, respectively.

The results of significantly higher TVFA in T2, the ration incorporated with 20 per cent unconventional feed coffee husk, as compared to T1, the conventional ration in this study, tend to agree with the findings of Konka *et al*. (2016) who reported that Murrah buffaloes fed on complete rations comprising of locally available crop residues as roughage source had a significantly higher TVFA content than those fed on the conventional grass-concentrate ration and Sarkar *et al*. (2019) who observed that the TVFA content of lactating red Chittagong cows fed on maize stover, a crop residue, based complete ration, was significantly higher than those fed on a conventional ration.

Similarity in TVFA content between treatments, which are in contrast to the findings of the present study were reported by Purushothaman (2018) who observed that the TVFA content of cross bred cows fed on complete rations containing dhanwantharam thailam residue and rapeseed cake at five percent level were similar.

5.2.2.10.3. Rumen ammonia nitrogen

The average values of rumen ammonia nitrogen in cows maintained on diets T1 and T2 were similar (P>0.05), with the values being 25.39 and 25.27 mg per 100 ml, respectively.

These values are comparable to the second and lower than the first group of Gupta *et al*. (2006) who reported that the rumen ammonia content of cross bred cattle fed on a berseem based complete ration were significantly higher than those fed on a wheat straw based complete ration, without green fodder; the values being 33.38, 22.44 mg per 100 ml, respectively. The findings of that study however, are in contrast to the present findings. The values obtained in the present study are comparable, but the findings are also in contrast to those of Chacko *et al.* (2017b) who reported that the rumen ammonia content of early lactation dairy cows fed on complete rations with 25 (T1), 30 (T2), and 35 (T3), per cent NDF, were 26.02, 25.21 and 22.83 mg

per 100 ml, respectively, with T3 being significantly lower than T1 and T2, with T1 and T2, being similar.

The values are comparable and the findings tend to agree with that of Raseel (2018) who found that the rumen ammonia levels of lactating dairy cows fed on complete feeds containing 1/3rd pineapple waste instead of maize in the conventional ration were similar, the values being 25.87, 25.45 mg per 100ml, respectively.

The results obtained in this investigation are in agreement with the findings of Kelzer *et al.* (2009) who found that the rumen ammonia nitrogen of lactating Holstein cows fed on complete feeds containing corn milling co-products at zero and 15 per cent level were similar and Badarinaa *et al*. (2013) who observed that the rumen pH of Napier grass based TMRs supplemented with fermented coffee husk at levels of 0, 10, 20, 30 and 40 per cent, were similar.

5.2.2.11. *In vitro* gas production parameters

The data on *in vitro* gas production parameters of the two experimental rations, T1 and T2 are shown in Table 25.

The corrected total gas production, ME and DOM of the two experimental rations, T1 and T2 were 28.67, 28.42 ml per 200 mg DM; 5.74, 5.74 MJ per kg DM and 43.51 and 43.24 per cent, respectively, with the values being similar (P>0.05).

Similarity in total gas production, ME, and DOM between treatments, as observed in this study were reported by Chacko *et al*. (2015) in *in vitro* gas production experiments conducted on complete feeds with NDF levels ranging from 25 to 35 per cent and Raseel *et al*. (2018) who reported that the ME and DOM values of complete feeds comprising of the conventional ingredient maize and another complete feed in which one third of the maize was replaced by pineapple waste were similar.

Contrasting results in the form of significantly higher values of net gas production, ME and DOM were reported by Lunagariya *et al*. (2017) who observed that maize stover based complete feeds for lactating cows supplemented with added

exogenous fibrolytic enzyme, at various levels, resulted in higher *in vitro* values for all these parameters as compared to an unsupplemented control.

5.2.2.12. Economics

The data on economics presented in Table 26 reveal that cows fed on diets T1 and T2 had DMI per kg milk production values of 0.84 and 0.89 kg, respectively. These values are lower and better than those reported by Chacko (2015) who obtained values in the range of 1.02 to 1.04 kg in early lactating dairy cows fed on complete rations having NDF levels ranging from 25 to 35 per cent and Raseel (2018) who got values of 1.28 and 1.18 kg in milking cows provided a conventional complete ration containing maize alone (T1) and another in which 1/3rd of the maize was replaced by pineapple waste (T2), respectively.

The values of cost per kg DM of complete rations, T1 and T2, used in the present study, shown in the same Table reveal that the values were Rs. 45.40 and 46.19, respectively for experimental rations T1 and T2, respectively. The cost per kg DM of complete rations T1, T2 and T3, used by Chacko (2015) were Rs. 27.51, 27.81 and 27.91, respectively and that used by Raseel (2018) were Rs.30.89 and 31.12 for T1 and T2, respectively; both of them in early lactation dairy cows, fed on paddy straw based complete rations; both of which were lower than that of the present investigation.

Cows fed on diets T1 and T2, in this experiment showed Rs. 37.97 and 41.04, respectively, as the cost of production of a kg of milk, with T2 having a higher cost of production by Rs. 3.07 than T1, ie., an 8.09 per cent increase. The cost of production values of both the groups were however higher than that of Chacko (2015) who reported costs of Rs.28.46, 28.26 and 29.22 per kg milk produced in cows fed on complete rations T1, T2 and T3, respectively and Raseel (2018) who reported cost per kg of milk production values of Rs. 36.82 and 34.22, respectively in his T1 and T2 groups, described above.

The possible reasons for the higher cost per kg DM and cost per kg milk production seen in this experiment *vis - a vis* the findings of Chacko (2015) and Raseel (2018) might be because of the reason that both the above works were carried out five and three years earlier, when the ingredient costs, processing and transportation charges, were much less and also because of the high overhead costs whcih occurred due to the fact that experimental complete feed production was executed on a very minor scale.

Correlating the data on economics given in Table 26 with the fortnightly average daily milk yield data given in Table 10, it can be seen that cows of group T2 fed showed a numerical (17.35 per cent), even though statistically non-significant ($P>0.05$) decrease in milk production than those in T1. These observations tend to agree with the findings of Taverez *et al*. (2005) who reported that replacement of corn with coffee hulls at 25 per cent level in TMR of Holstein-Zebu cows, receiving adequate amount of concentrate feed stuffs, resulted in a significant decrease in milk production; even though coffee hull incorporation, reduced the cost per kg of TMR, by 19 per cent. Those workers concluded that the lowering of feed cost on account of coffee hull incorporation, which tended to agree with the 8.15 per cent lower cost per kg fresh feed in T2 (Rs. 22.21) than T1 (Rs. 24.02), in the present study; did not compensate for the reduced milk yield, which ultimately resulted in reduced profit, in their study, which can be compared to the Rs. 3.07 increase (8.09 %) in cost per kg milk production in T2, with coffee husk as compared to T1, without coffee husk.

An overall critical evaluation of the results of the present investigation, revealed that both the grass based complete rations T1 and T2, performed well, as indicated by the absence of NEB in both the groups; normal milk composition parameters such as TS, fat, SNF, protein and MUN; normal haemato - biochemical and rumen fermentation parameters in cows of both the groups. However, among the two grass based complete rations, used in this study; T2, formulated with the protein rich unconventional byproduct feed, coffee husk, the best unconventional protein rich

feed selected from the *in vitro* study; which replaced 1/3rd of the CP in T1, on DM basis; was not as effective as T1, in eliciting production performance in early lactation dairy cows, as evinced by the significantly lower DMI; numerically lower, but statistically non- significant milk yield; significantly lower fat corrected milk yield, fat and protein yield; significantly lower digestibility coefficients of all nutrients, higher feed cost per kg DM (even though feed cost per kg fresh feed was less) and higher cost per kg milk production in T2 than T1.

The probable reason for the same could be attributed to the findings of Taverez *et al*. (2005) who observed that coffee husk, contained phytochemicals such as tannin and caffeine, which have got intake reducing characteristics, as result of which feed and subsequently nutrient intake got reduced. Tannin present in coffee husk could have bound with protein and carbohydrate in the rumen, whereby digestion and absorption of protein and carbohydrate, might have got reduced (Badarinaa *et al*., 2013), with subsequent reduction in milk yield and consequent increase in the cost per kg milk production in T2, the coffee husk incorporated ration, as compared to T1, the conventional grass based complete ration.

From a thorough scrutiny of this experiment, it can be inferred that, incorporation of coffee husk at lower levels, in ration T2; such as replacing 1/4th or 1/5th of the total protein of the ration T1, would probably have been effective, instead of 1/3rd replacement adopted in this study. Therefore, further studies, envisaging incorporation of coffee husk, as a protein rich unconventional feed source, at levels, lower than that used in the present study are warranted. Nevertheless, grass based complete rations with minimum of green fodder, such as the ones used in this study, can be recommended for use among dairy farmers in Kerala, wherever green fodder is available in plenty. Concomitant incorporation of locally available unconventional feeds, to the maximum possible extent, will help to reduce feed cost. It is also advised that bulk production of complete feed should be carried out, so that feed cost can be restricted within the affordable limits of dairy farmers.

6. SUMMARY

An experiment was conducted to assess, evaluate and compare, conventional and unconventional feed ingredients based complete feeds in early lactation dairy cows on the basis of production performance and economics. Four locally available unconventional feeds/ byproducts, which are rich source of protein, viz., tapioca leaf meal (*Manihot esculenta)*, tea waste (*Camellia sinensis*), coffee husk (*Coffea arabica*) and pepper waste (*Piper nigrum*) were procured. These feeds were tested *in vitro* by the *in vitro* gas production technique (IVGPT) to estimate the metabolisable energy (ME), digestible organic matter (DOM) and *in vitro* degradable nitrogen (IVDN) content in the feeds. The crude protein content of the above feeds were determined by standard procedure (AOAC 2016).

These four protein rich unconventional feeds were ranked on the basis of scores obtained in a four point ranking system. Individual scores were assigned for the four feed ingredients tested and the feed ingredient having the highest aggregate score was selected as the best feed ingredient, which was further tested *in vivo*. Coffee husk, which obtained the highest aggregate total score of 11, was selected for further *in vivo* study.

Two complete rations, which are isoproteimic (12 to 13 per cent CP) and isocaloric (64 to 65 per cent TDN); T1 with conventional feed ingredients and T2 with one third of the CP in T1, being replaced by coffee husk, were formulated as per ICAR (2013). Twelve early lactating cows yielding approximately 18 kg of milk per day and within ten days of lactation were selected, divided into two groups of six each and allotted randomly to the two experimental rations in a feeding trial of 90 days duration.

Individual records were maintained for daily dry matter intake (DMI), milk yield, fortnightly body weight and milk composition parameters such as fat, SNF, total solids, milk protein and milk urea nitrogen (MUN). Haemato - biochemical parameters such as glucose, BUN, Ca and P were estimated from blood samples

collected at the initial and final phase of the feeding trial. The digestibility coefficients of nutrients were determined by a digestibility trial of five days duration, conducted towards the end of the experiment. *In vitro* gas production of the rations and rumen fermentation parameters of cows were estimated, following the feeding trial. The data generated in the experiment were analysed, statistically.

Perusal of the data revealed that the body weight of cows in groups T1 and T2 were similar ($P>0.05$) in all fortnights. The body weight increased from the beginning, till the end of the experiment, indicating that there was no negative energy balance (NEB). The DMI, DMI per 100 kg body weight and DMI per kg metabolic body weight of cows of T1 was significantly higher ($P<0.05$) than those fed on T2.

The initial milk yield of cows in T1 and T2 were 17.97 and 18.03 kg, respectively. Cows in T1 reached peak milk yield early and had greater persistency of milk yield than those in T2. The final milk yield of cows in T1 and T2 were 17.45 and 14.87 kg, respectively. Even though there was no significant difference ($P>0.05$) in average daily milk yield of cows in T2 was numerically lower by 2.58 kg (17.35 per cent) as compared to those in T1.

There was no significant difference ($P>0.05$) in milk composition parameters such as milk fat, total solids, SNF, milk protein and MUN between the two dietary treatments; with the values being similar and in the normal range of lactating dairy cows. The fortnightly average fat corrected milk (FCM) yield, fat and protein yield of cows in T1 were significantly higher ($P<0.01$) than those in T2 and there was no incidence of any off flavour in milk.

Hematological parameters such as glucose and BUN as well as plasma mineral parameters like Ca and P were similar ($P>0.05$) and in the normal range for dairy cows. Cows of T1 had a significantly higher ($P<0.05$) digestibility coefficient for all nutrients such as DM, OM, CF, CP, EE, NFE, NDF and ADF than those of T2.

The IVGPT parameters such as corrected total gas production, ME and DOM, as well as the rumen fermentation parameters such as rumen pH and rumen ammonia

nitrogen were similar (P>0.05), but the total volatile fatty acid content of cows in T2 was significantly higher (P<0.05) than those of T1.

Cows fed on diets T1 and T2 had a DMI of 0.84 and 0.89 kg, respectively for every kg of milk produced. Cows fed on rations T1 and T2 showed Rs. 37.97 and 41.04, respectively, as the cost of production of a kg of milk, with T2 having a higher cost of production by Rs. 3.07 than T2, ie., an 8.09 per cent increase.

An overall critical evaluation of the results of the present investigation, revealed that both the grass based complete rations T1 and T2, performed well, as indicated by the absence of NEB, normal milk composition, haemato - biochemical and rumen fermentation parameters in cows of both the groups. However, it could be seen that among the two grass based complete rations, T2 was not as effective as T1, in eliciting production performance in early lactation dairy cows, as evinced by the significantly lower DMI; numerically lower, but statistically non- significant milk yield; significantly lower fat corrected milk yield, fat and protein yield; significantly lower digestibility coefficients of all nutrients and higher cost per kg milk production in T2 than T1. Cows of T1 reached peak milk yield early and had greater persistency of milk yield than those in T2.

From a thorough scrutiny of this experiment, it can be inferred that, incorporation of coffee husk at lower levels, in ration T2; such as replacing $1/4^{th}$ or $1/5^{th}$ of the total protein of the ration T1, would probably have been effective, instead of $1/3^{rd}$ replacement adopted in this study, for which further studies are required.

Nevertheless, grass based complete rations with minimum of green fodder, such as the ones used in this study, can be recommended for use among dairy farmers in Kerala, wherever green fodder is available in plenty. Concomitant incorporation of locally available unconventional feeds, to the maximum possible extent, will help to reduce feed cost. It is also advised that bulk production of complete feed should be carried out, so that feed cost can be restricted within the affordable limits of dairy farmers.

REFERENCES

Amata, I.A. 2015. The use of non-conventional feed resources (NCFR) for livestock feeding in the tropics: A Review. *J. Nat. Prod. Pl. Resour*. **5**(5): 7-15.

Antaya, N.T., Soder, K.J., Kraft, J., Whitehouse, N.L., Guindon, N.E., Erickson, P.S., Conroy, A.B. and Brito, A.F. 2015. Incremental amounts of *Ascophyllum nodosum* meal do not improve animal performance but do increase milk iodine output in early lactation dairy cows fed high-forage diets. *J. Dairy Sci.* **98**(3): 1991–2004.

AOAC. 2016. Official Methods of Analysis (19th Ed.). Association of Official Analytical Chemistry Washington, D. C. pp 24-77.

Badarinaa, I., Evvyernieb, D., Toharmatb, T., Herliyanac, E.N. and Darusman, L.K. 2013. Nutritive value of coffee husk fermented with *Pleurotus ostreatus* as ruminant feed. *Media Peternakan*. **36**(1): 58-63.

Banakar, P.S. 2016. Nutritive evaluation of unconventional feeds using *in vitro* gas production technique. *M.V.Sc. Thesis.* Kerala Veterinary and Animal Sciences University, Pookode, Kerala. 101p.

Bargo, F., Muller, L.D., Delahoy, J.E and Cassidy, T.W. 2002. Performance of high producing dairy cows with three different feeding systems combining pasture and total mixed rations. *J. Dairy Sci*. **85**(11): 2948 - 2963.

Barnett, A. J. G. and Reid, R. L. 1957. Studies on the production of volatile fatty acids from grass by rumen liquor in an artificial rumen. 1. The volatile fatty acid production from fresh grass. *J. Agri. Sci. Camb.* **48**: 315-321.

Bartsch, B.D and Wickes, R.B. 1979. Citrus meal as an energy supplement for dairy cows *Aust. J. Exp. Agric. Anim. Husb.* **19**(101): 658 – 662.

Bector, B.S., Ram, M. and Sighal, O.P. 1998. Rapid platform test for detection of added urea in milk. *Indian Dairyman*. **50**(4): 59-62.

Beecher, G.P. and Whitten, B.K. 1970. Ammonia determination: Reagent modification and interfering compounds. *Analyt. Biochem*. **36**: 243.

Beigh, Y.A., Ganai, A.M., and Ahmad, H.A. 2017. Prospects of complete feed system in ruminant feeding: A review. *Vet. World*. **10**(4): 424-437.

Boguhn, J., Kluth, H., Bulang, M., Engelhard, T. and Rodehutscord, M. 2010. Effects of pressed beet pulp silage inclusion in maize-based rations on performance of high yielding dairy cows and parameters of rumen. *Animal*. **4**(1): 30-39.

Chacko, B. 2015. Evaluation of complete feeds with varying levels of neutral detergent fibre for lactating dairy cows. *Ph.D. Thesis.* Kerala Veterinary and Animal Sciences University, Pookode, Kerala. 250p.

Chacko, B., Mohan, S.K.M., Ally, K., Shyama, K., Anil, K.S. and Sathian, C.T. 2015. Evaluation of paddy straw based complete feeds with different levels ofneutral detergent fibre by *in vitro* gas production technique. *Indian J. Vet. Anim. Sci. Res*. **44**(6): 374-382.

Chacko, B., Mohan, S.K.M., Ally, K., Shyama, K., Anil, K.S. and Sathian, C.T. 2016. Production performance of cows reared on complete feeds with varying levels of neutral detergent fibre (NDF) as against the conventional grass-concentrate feeding system in Kerala. *J. Vet. Anim. Sci*. **47**(1): 36-41.

Chacko, B., Mohan, S.K.M., Ally, K., Shyama, K., Anil, K.S. and Sathian, C.T. 2017a. Effect of paddy straw plus non-forage fiber sources based complete rations with different levels of neutral detergent fiber on hemato-biochemical and mineral profile of lactating dairy cows. *Vet. World*. **10**(7): 836-842.

Chacko, B., Mohan, S.K.M., Ally, K., Shyama, K., Anil, K.S. and Sathian, C.T. 2017b. Effect of paddy straw plus non-forage fibre sources based complete rations with different levels of neutral detergent fibre on rumen fermentation parameters in lactating dairy cows. *Indian J. Anim. Nutr*. **34**(3):352-356.

Chacko, B., Mohan, S.K.M., Ally, K., Shyama, K., Anil, K.S. and Sathian, C.T. 2018. Milk composition of lactating dairy cows fed on paddy straw based complete rations containing different levels of neutral detergent fibre (NDF). *Indian J. Dairy Sci.* **71**(3): 258-266.

Chacko, B., Mohan, S.K.M., Ally, K., Shyama, K., Anil, K.S. and Sathian, C.T. 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. *Int. J. Livestock Res.* **9**(6): 148-156.

Chacko, B., Mohan, S.K.M., Ally, K., Shyama, K. 2020. Effect of paddy straw plus non-forage fibre sources based complete feeds containing different lvels of neutral detergent fibre on body weight and reproductive parameters of lactating dairy cows. *Ind. J. Pure App. Biosci*. **8**(2): 86-94.

Choi, Y., Rim, J., Lee, H., Kwon, H., Na, Y. and Lee, S. 2019. Effect of fermented spent instant coffee grounds on milk productivity and blood profiles of lactating dairy cows. *Asian-Aust. J. Anim. Sci.* **32**(7): 1007–1014.

Datta, D. 2013. Indian Fodder Management towards 2030: A case of vision or myopia. *Int. J. Mgmt. and Social Sci. Res.* **2**(2): 2319-4421.

Delahoy, J.E., Muller, L.D., Bargo, F., Cassidy, T.W. and Holden, L.A. 2003. Supplemental carbohydrate sources for lactating dairy cows on pasture. *J. Dairy Sci.* **86**(3): 906–91.

Delany, K.K., Macmillan, K.L., Grainger, C., Thomson, P.C., Blache, D., Nicholas, K.R. and Auldist, M.J. 2010. Blood plasma concentrations of metabolic hormones and glucose during extended lactation in grazing cows or cows fed a total mixed ration. *J. Dairy Sci.* **93**(12): 5913-5920.

Einarson, M.S., Plaizier, J.C., Wittenberg, K.M. 2004. Effects of barley silage chop length on productivity and rumen conditions of lactating dairy cows fed a total mixed ration. *J. Dairy Sci.* **87**(9): 2987–2996.

Eruden, B., T., Nishida, H., Matsuyama, K.H. and Shioya, S. 2005. Effect of the addition of various levels of green tea grounds silage at on the feed intake and milk production in lactating dairy cows. *Anim. Sci. J.* **76**: 295–301.

Girdhar, N. and Balaraman, N. 2005. Nutrient utilisation, balances of Ca, P and N in lactating crossbred cows fed berseem fodder based total mixed ration containing different levels of energy and protein. *Indian J. Anim. Sci.* **75**(1): 47-51.

Government of India. 2017. 19th Livestock Census-2012 All India Report. *Ministry of Agriculture.* New Delhi. pp 14-39.

Gulati, A., Galvin, N., Lewis, E., Hennessy, D., Donovan, M., Jennifer, J., Manus, M., Fenelon, M.A. and Guinee, T.P. 2017. Outdoor grazing of dairy cows on pasture versus indoor feeding on total mixed ration: Effects on gross composition and mineral content of milk during lactation. *J. Dairy Sci.* **101**: 2710–2723.

Gupta, R.B., Tiwari, D.P. and Kumar, A. 2006. Effect of feeding complete ration *vis-à-vis* conventional ration on nutrient utilisation and rumen metabolism in crossbred cattle. *Indian J. Anim. Sci.* **76**(1): 55-60.

Gupta, J.J., Dey, A., Bhatt, B.P., Chakrabarti, A., Dayal, S., Kumari, R. and Bharti, S.K. 2014. Performance of lactating crossbred cows fed on forage based total mixed ration. *J. Livestock. Res. Int.* **2**(2): 30-32.

Hundal, J.S., Gupta, R.P., Wadhwa, M. and Bakshi, M.P.S. 2004. Effect of feeding total mixed ration on the productive performance of dairy cattle. *Anim. Nutr. Feed Technol*. : 179-186.

ICAR. 2013. *Nutrient requirements of Animals – Cattle and Buffalo.* (3rd Ed.). Indian Council of Agricultural Research, New Delhi. p. 24.

IS: 1224. 1977. *Determination of fat by Gerber's method*. Part I. Milk (1st revision). Indian Standards Institution. New Delhi. p. 18.

Jeong, C.D., Mamuad, L.L. Ko. J.Y. Sung, H.G. Park, K.K., Lee, Y.K. and Lee, S.S. 2016. Rumen fermentation and performance of hanwoo steers fed total mixed ration with Korean rice wine residue. *J. Anim. Sci. and Technol.* **58**(4): 1-7.

Kajla, J.S. Grewal, R.S., Kaur, J., Lamba, J.S., Kaur, S. and Malhotra, P. 2019. Effect of total mixed ration feeding with roughage concentrate ratio of 60:40 on performance and residual feed intake of crossbred cows. *Int. J. Curr. Microbiol. App. Sci.* **8**(4): 2866-2870.

Kennedy, E., Lewis, E., Murphy, J.P., Galvin, N. and Donovan, M.O. 2015. Production parameters of autumn calving cows offered either a total mixed

ration or grazed grass plus concentrate during early lactation. *J. Dairy. Sci.* **98**(11): 7917-7929.

Kelzer, J.M., Kononoff, P.J., Gehman, A.M., Tedeschi, L.O., Karges, K. and Gibson, M.L. 2009. Effects of feeding three types of corn-milling coproducts on milk production and ruminalfermentation of lactating Holstein cattle. *J. Dairy Sci.* **92**(10): 5120–5132.

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.

Kim, S.H., Alam, M.J., Gu, M.J., Park, K.W., Jeon, C.O., Ha, J.K., Cho, K.K. and Lee, S.S. 2012. Effect of total mixed ration with fermented feed on ruminal *in vitro* fermentation, growth performance and blood characteristics of Hanwoo steers. *Asian-Aust. J. Anim. Sci.* **25** (2): 213-223.

Kishore, K., Kumar, D., Ramana, J.V. and Rao, E. 2017. Prospects of total mixed ration (TMR) in livestock production. *Bull. Env. Pharmacol. Life Sci.* **6**(3): 90-95.

Koakhunthod, S., Wanapat, M., Wachirapakorn, C., Nontaso, N. Rowlinson, P. and Sornsungnern, N. 2001. Effect of cassava hay in high-quality feed block supplementation on milk production in lactating dairy cows. In: *Proc. International Workshop on Current Research and Development of Cassava as Animal Feeds* (Ed. Preston, T.R., Ogle, B. and Wanapat, M.). Khon Kaen University and Swedish International Development Agency (SIDA) and Swedish Agency for Research and Cooperation with Developing Countries (SAREC). July 23-24. Khon Kaen, Thailand. pp. 21-25.

Kondo, M., Nakno, M., Kaneko, A., Agata, H., Kita, K. and Yokota, H. 2004. Ensiled green tea waste as partial replacement for soyabean meal and alfalfa hay in lactating cows. *Asian- Aust. J. Anim. Sci*. **17**(7): 960-966.

Konka, R.K., Kumar, D., Dhulipalla, S.K., Ramana, J.V., Ravi, A., and Rao, E. 2016. Fermentation pattern in Murrah buffalo bulls fed on crop residue based

complete rations vis-a- vis conventional feeding. *Anim. Nutr. Feed Technol*. **16**(1): 171-179.

Lade, M.H., Tiwari, D.P and Kumar, A. 2007. Effect of feeding complete ration *vis-a-vis* conventional ration with and without green fodder on nutrient utilization and lactation performance in crossbred cows. *Indian J. Anim. Sci.* **77**(10): 1026-1033.

Li, D.Y., Lee, S.S., Choi, N.J., Lee, S.Y., Sung, H.Y., Ko, J.Y., Yun, S.G. and Ha, J.K. 2003. Effects of feeding system on rumen fermentation parameters and nutrient digestibility in Holstein steers. *Asian-Aust. J. Anim. Sci.* **16**(10): 1482-1486.

Lunagariya, P.M., Gupta, R.S. and Parnerkar, S. 2017. *In vitro* evaluation of total mixed ration supplemented with exogenous fibrolytic enzymes for crossbred cows. *Vet. World*. **10**(3): 281-285.

Lunsin, R., Wanapat, M. and Rowlinson, P. 2012. Effect of cassava hay and rice bran oil supplementation on rumen fermentation, milk yield and milk composition in lactating dairy cows. *Asian Aust. J. Anim. Sci.* **25**(10): 1364-1373.

Maulfair, D.D., Fustini, M. and Heinrichs, A.J. 2011. Effect of varying total mixed ration particle size on rumen digesta and fecal particle size and digestibility in lactating dairy cows. *J. Dairy Sci*. **94**: 3527–3536.

McDonald, P., Edwards, R., Morgan, C. A. and Greenhalgh, J. F. D. 2002. *Animal Nutrition* (6th Ed.). Longman Singapore publishers Pvt. Ltd., Singapore, 693p.

Menke, K.H. and Steingass, H. 1988. Estimation of the energetic feed value obtained from chemical analysis and gas production using rumen fluid. *Anim. Res. Dev*. **28**: 7-55.

Milma, 2017. Kerala Cooperative Milk Marketing Federation Ltd. *Annual Report 2016-2017*. 146p.

Muhanned, .E.M., Mohammad, A., Gorgulu, M. and Goncu, S. 2017. The effects of total mixed ration and separate feeding on lactational performance of dairy cows. *Asian Res. J. of Agri.* **5**(2): 1-7.

Nagalakshmi, D., Reddy, D and Kirubananth, K. 2003. Effect of processing cotton straw based complete diet with expanderextruderon performance of crossbred calves. *Asian-Aus. J. Anim. Sci.* **16**(11): 1572-1576.

Nagalakshmi, D., Reddy, D. and Prasad, M. 2013. Effect of feeding red gram stalks based complete diets on nutrient utilization and plane of nutrition in buffaloes. *Indian J. Anim. Res.* **48**(3): 231-235.

NDDB 2019. *Official website of the National Dairy Development Board.* Accessedonline at https://www.nddb.coop/information/stats/milkprodindia

Nha, B. and Pattarajinda, V. 2019. Effect of physically effective neutral detergent fibre and moisture content in fermented total mixed ration on lactating cow performance. *Indian J. Anim. Res.* **53**(7): 913-917.

NRC 2001. Nutrient requirements for dairy cattle. (7th Ed). *National Acad. Sci*., Washington, D.C. USA. p. 408.

Ortega, M.H., Fernandez, A.M., Soldado, A., Gonalez, A., Jordan, M.A., Argamenteria, A., Delgado, R. and Vicente, F. 2014. Effect of total mixed ration composition and milk production, composition and fatty acids profile of dairy cows. *J. Dairy Res.* 81(4): 471-478.

Owen, J.B. 1984. Complete diet feeding for cattle. *Livestock. Prod. Sci.* **11**(3): 269-285.

Kerala State Planning Board 2017. Economic Review 2017. Official website of the Planning Board. Government of Kerala. Accessed online at http://spb.kerala.gov.in/ER2017/web.

Pandya, P.R., Desai, M.C., Patel, G.R., Talpada, P.M., Pande, M.B. and Parnerkar, S. 2009. Economical rearing of crossbred calves on complete feeds, based on sugarcane bagasse and non conventional feeds. *Indian J. Anim. Nutr*. **26**(3): 211-215.

Prasad, K., Savale, S., Mahantesh, M.T., Pavan, M., Barman, D. and Abraham, J. 2017. Socio-economic profile and constraints faced by dairy farmers of Wayanad district *Int. J. Curr. Microbiol. App. Sci.* **6**(6): 870-874.

Purushothaman, S. 2018. Evaluation of rumen fermentation pattern and nutrient utilization in Murrah buffalo, Vechur and crossbred cattle on different

feeding regimen. *Ph.D. Thesis.* Kerala Veterinary and Animal Sciences University, Pookode, Kerala. 170p.

Raab, L., Cafantaris, B., Jilg, T. and Menke, K.H. 1983. Rumen protein degradation and biosynthesis. A new method for determination of protein degradation in rumen fluid *in vitro. Br. J. Nutr.* **50**: 569-582.

Raseel, K. 2018. Evaluation of *unconventional* feed based complete rations for crossbred dairy cows in early lactation. *M.V.Sc. Thesis*. Kerala Veterinary and Animal Sciences University, Pookode, Kerala. 100p.

Raseel, K., Chacko, B., Sunanda, C., Dildeep, V. and Abraham. J. (2018). Nutrient evaluation of energy rich unconventional feeds available in Wayanad. *Int. J. Sci. Nature.* **9**(1): 117-118.

Rathinavelu, R. and Graziosi, G. 2005. Potential alternative use of coffee waste and by-products. International Coffee Organization, 1967-05. pp: 1-2.

Roy, A.K., Agrawal, R.K., Bhardwaj, N.R., Mishra, A.K. and Mahanta, S.K. 2019. Revisiting national forage demand and availability scenario In**:** *Indian Fodder Scenario: Redefining State Wise Status.* ICAR- AICRP on Forage Crops and Utilization, Jhansi, India, pp. 1-21.

Roza, E., Nurdin, M.S. and Aritonang, S.N. 2013. Digestibility test of cassava leaves in feed supplement on buffaloes by *in-vitro. Pakistan J. Nutr*. **12** (5): 505-509.

Saijpaul, S., Grewal, R.S., Kaur, R. and Naik, P.K. 2005. Evaluation of some potential complete rations on economic milk production in crossbred cows. *Anim. Nutr. Feed Technol*. **5**: 203-210.

Sarkar, N.R., Yeasmin, D., Habib, M.A. and Tabassum, M. 2019. Feeding effect of total mixed ration on milk yield, nutrient intake, digestibility and rumen environment in Red Chittagong cows. *Asian J. Med. Bio. Res.* **5**(1): 71-77.

Scharen, M., Jostmeier, S., Ruesink, S., Hüther, L., Frahm, J., Bulang, M., Meyer, U., Rehage, J., Isselstein, J., Breves, G.and Dänicke, S. 2015. The effects of a ration change from a total mixed ration to pasture on health and production of dairy cows. *J. Dairy Sci*. **99**(2): 1183–1200.

Silva, F.G.B.D., Yamamoto, S.M., Queiroz, M.A.A., Gordiano, L.A. and Formiga, M.A. 2015. Propolis extract and sodium monensin on ruminal fermentation and hematological parameters in sheep. *Acta Scientiarum. Anim. Sci.* **37**(3): 273-280.

Snedecor, G.W. and Cochran, W.G. 1994. *Statistical Methods*. (8th Ed.). The Iowa State University Press, Ames, IA. 314p.

Sundarman, A., Listiawan, G.B. and Khodijah, L. 2019. The use of coffee husk as Napier grass substitution and its effect on Madura cattle performance. *Indonasian J. Anim. Vet. Sci.* **24**(4): 166-172.

Susanti, E., Agus, A., Suranindyah, Y.Y. and Suhartati, F.M. 2015. Quality evaluation of complete feed with ramie waste added with different protein source in nutrient composition and ensilage parameter. *Anim. Prod.* **17**(1): 35-41.

Tavares, A.A.C., Pereira, M.N., Tavares, M.R. and Chaves, M.L. 2005. Performance of Holstein-Zebu cows under partial replacement of corn by coffee hulls. *Sci. Agric. (Piracicaba, Braz.).* **62**(2): 1590-1561.

Tshome, D., Fita, L., Feyissa, F., Kitaw, G. and Wondatir, Z. 2017. Effect of total mixed ration on dry matter intake, milk yield and composition of early lactating Jersey cows. *J. Biol. Agric. Healthcare*. **7**(9): 19-24.

Tozer. P.R., Bargo, F. and Muller, L.D. 2003. Economic analyses of feeding systems combining pasture and total mixed ration. 2003. *J. Dairy Sci.* **86**: 808–818.

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.

Wachirapakorn, C., Pilachai, K., Wanapat, M., Pakdee P. and Cherdhthong, A. 2016. Effect of ground cob as a fibre source in total mixed ration on feed intake, milk yield and milk composition in tropical lactating crossbred Holstein cows. *J. Anim. Nutr.* **2**: 334- 338.

Wanapat, M., Puramongkon, P. and Siphuak, W. 2000. Feeding of cassava hay for lactating dairy cows. *J. Asian-Aus. Anim. Sci.* **13**(4): 478.

Xu, C., Cai, Y., Moriya, N., Hosoda, K. and Matsuyama, H. 2008. The effect of replacing brewer's grains with barley tea grounds in total mixed ration silage on feed intake, digestibility and ruminal fermentation in wethers. *J. Anim. Sci.* **79**: 226-239.

Zebeli, Q., Dijkstra, J., Tafaj, M., Steingass, H., Ametaj, B.N. and Drochner, W. 2008. Modelling the adequacy of dietary fibre in dairy cows based on the responses of ruminal pH and milk fat production to the composition of the diet. *J. Dairy Sci.* **91**(5): 2046 – 2066.

EVALUATION OF COMPLETE RATIONS CONTAINING UNCONVENTIONAL FEEDS IN EARLY LACTATING DAIRY COWS

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(16-MVP-012)

ABSTRACT

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7. ABSTRACT

An investigation was carried out for the comparative evaluation of conventional and unconventional feed ingredients based complete feeds in early lactating cows on the basis of production performance and economics. Four locally available unconventional feed ingredients which are rich sources of protein, viz., tapioca leaf meal, tea waste, coffee husk and pepper waste were tested *in vitro* to estimate the ME, DOM, IVDN and CP. These ingredients were ranked on the basis of a four point ranking system and coffee husk, the one which had the highest aggregate total score was selected as the best feed ingredient, which was further tested *in vivo.*

Two complete rations, which are isoproteimic (12 to 13 per cent CP) and isocaloric (64 to 65 per cent TDN); T1 with conventional feed ingredients and T2 with one third of the CP in T1, being replaced by coffee husk, were formulated as per ICAR (2013). Twelve early lactating cows yielding approximately 18 kg of milk per day and within ten days of lactation were selected, divided into two groups of six each and allotted randomly to the two experimental rations in a feeding trial of 90 days duration.

On perusal of the data, it could be seen that the body weight of cows fed on the two rations, T1 and T2 were similar ($P>0.05$) in all fortnights and increased from the beginning, till the end of the experiment, indicating that there was no negative energy balance (NEB).

The average daily dry matter intake (DMI), DMI per 100 kg body weight and DMI per kg metabolic body weight of cows fed on experimental ration T1 was significantly higher ($P<0.05$) than those fed on T2.

Cows fed on ration T1 reached peak milk yield early and had greater persistency of milk yield than those in T2. The average daily milk yield of cows in T1 and T2 were 17.45 and 14.87 kg, respectively. Even though there was no significant difference ($P>0.05$), the average daily milk yield of cows in group T2 was numerically lower by 2.58 kg (17.35 per cent), as compared to those in group T1.

Milk composition parameters such as milk fat, total solids, SNF, milk protein and MUN, were similar ($P>0.05$) between cows fed on the two dietary treatments, with all parameters being in the normal range for lactating dairy cows.

The fortnightly average fat corrected milk (FCM) yield, fat and protein yield of cows in T1 were significantly higher ($P<0.01$) than those in T2. There was no incidence of any off flavour in milk from cows maintained on the two rations in the entire experimental period.

Hematological parameters such as glucose and BUN as well as the plasma mineral parameters, viz., Ca and P were similar ($P>0.05$) between the two dietary treatments and were in the normal range for lactating dairy cows.

Digestibility coefficient of all nutrients such as DM, OM, CF, CP, EE, NFE, NDF and ADF of cows fed on ration T1 was significantly higher ($P<0.05$) than those fed in T2.

The rumen fermentation parameters such as rumen pH and rumen ammonia nitrogen were similar ($P>0.05$) among cows belonging to the two dietary treatments, while the TVFA content of cows fed on ration T2 was significantly higher ($P<0.05$) than those of T1.

The IVGPT parameters such as corrected total gas production, ME and DOM of the two experimental rations, T1 and T2 were similar ($P>0.05$).

The cost of production of one kg of milk was Rs. 37.97 and 41.04, in T1 and T2, respectively, with T2 having a higher cost of production of Rs.3.07 than T1 (8.09 %).

An overall critical evaluation of the results of the present investigation, revealed that both the grass based complete rations T1 and T2, performed well, as indicated by the absence of NEB; normal milk composition, haemato - biochemical and rumen fermentation parameters in cows of both the groups. However, it could be seen that among the two rations, T2 was not as effective as T1, in eliciting production performance in early lactation dairy cows, as evinced by the significantly lower DMI;

numerically lower, but statistically non - significant milk yield; significantly lower FCM yield, fat and protein yield; significantly lower digestibility coefficients of all nutrients and higher cost per kg milk production in T2 than T1.

From a thorough scrutiny of this experiment, it can be inferred that, incorporation of coffee husk at lower levels, in ration T2; such as replacing $1/4^{th}$ or $1/5^{th}$ of the total protein of the ration T1, would probably have been effective, instead of $1/3^{rd}$ replacement adopted in this study, for which further studies are required. Nevertheless, it can be concluded that grass based complete rations, with incorporation of locally available unconventional feeds such as coffee husk, to the maximum possible extent, which will help to reduce the feed cost, without compromising on production performance. It is also advised that bulk production of the same should be carried out, so that feed cost can be restricted within the affordable limits of dairy farmers.

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CURRICULUM VITAE

1. Name of the candidate : RASANATH K

2. Date of birth : 02-04-1992

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5. Permanent address : Shabnam House, Ambilery,
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6. Major field of specialisation : Animal Nutrition

7. Educational status : B.V.Sc. & A.H

8. Professional experience : 1) Worked as Veterinary surgeon in
Animal Husbandry Department of
Kerala

9. Publications made : Number of published papers-1

10. Membership of professional socieites : 1) Member of Indian Veterinary
Association, Wayand

Academic Form No.19

KERALA VETERINARY AND ANIMAL SCIENCES UNIVERSITY

FACULTY OF VETERINARY AND ANIMAL SCIENCES

PROGRAMME OF RESEARCH WORK FOR THESIS FOR MASTER'S DEGREE

1. Title of Thesis:

Evaluation of complete rations incorporating unconventional feeds in early lactating cows

2(a). Title of the departmental/ KVASU research project of which this forms a part: NA

2(b). Code No. if any and order by which departmental/KVASU research project is approved: NA

3(a). Name of the student

Rasanath. K

3(b). Admission No.

16-MVP-12

4(a). Name of the major advisor

Dr. Biju Chacko

(b). Designation

Assistant Professor

Department of Animal Nutrition, College of Veterinary and Animal Sciences, Pookode, Lakkidi P.O. Wayanad- 673 576

5. Objectives of the study

1. Study of *in vitro* digestion parameters of four unconventional feed ingredients
2. Evaluation of complete rations containing unconventional feed/ byproducts in early lactating cows
3. Economics of production

6. Practical/Scientific utility

High feed cost coupled with scarcity of fodder and reduced availability of land for fodder cultivation are the major constraints faced by the dairy farmers of Kerala. Addition of locally available unconventional feeds/ byproducts is a solution, but the low palatability of these feeds limits their incorporation in dairy cattle rations. This has necessitated a situation, where in, we have to explore ways of providing feed in the form of complete diets, which involve processing the concentrate and roughage ingredients together into a well mixed blend.

Complete feeds formulated using conventional feed ingredients are costlier than those formulated with unconventional feeds. Formulation of complete feeds using unconventional feeds/ byproducts, without compromising on milk production, shall help a

great deal in economic milk production and shall also serve as a good medium for agro-industrial waste utilisation.

7. Important publications on which study is based

Wanapat *et al.* (2000) reported that lactating Holstein Friesian cross bred cows fed on cassava hay based complete ration at the rate of 1.70 kg per head per day had significantly higher fat corrected milk yield, milk fat and protein percentage than those fed on the unsupplemented control ration.

Rathinavelu and Graziosi (2005) reported that coffee husk can replace upto 20 percent of commercial concentrate in dairy cattle feeding with 30 percent savings in cost.

Xu *et al.* (2008) conducted a feeding trial in wethers and reported that substitution of wet brewers grains, which formed 30 percent of TMR, with wet barley tea grounds at 5, 10 and 15 percent levels, significantly increased the digestibility coefficient of dry matter (DM) and gross energy.

Zebeli *et al*. (2008) observed that 30 to 33 percent NDF was the optimum level of NDF in complete feeds and feeding of complete feeds containing NDF in the above range was essential for minimizing the risk of subacute ruminal acidosis, without impairing production responses in high yielding dairy cows.

Boguhn *et al.* (2010) studied the effect of replacement of low NDF maize with high NDF beet silage in TMR for dairy cows by conducting *in vitro* studies and reported that the intensity of fermentation as well as microbial protein synthesis was lower while organic matter digestibility and ME concentration were higher in the high NDF beet silage based TMR as compared to the low NDF maize based TMR. A simultaneous *in vivo* study conducted using the same two TMRs revealed that milk yield, milk fat and protein content were similar.

Chacko (2015) reported that complete rations containing paddy straw as the sole source of roughage, with 25 to 35 percent NDF can be recommended for use among early and mid lactation dairy cows of Kerala, with 35 percent being the ideal NDF level, in terms of milk production and economics.

Chacko *et al.* (2016) reported that lactating dairy cows fed on paddy straw based complete rations containing 25, 30 and 35 percent NDF had a significantly higher dry matter intake, milk yield, income from sale of milk, came into heat earlier and had better conception rate than those fed on conventional grass-concentrate system.

8. Outline of technical programme.

Four locally available unconventional feeds/ byproducts viz., tapioca (*Manihot esculenta)* leaf meal, tea (*Camellia sinensis*) waste, coffee (*Coffea arabica*) husk and pepper (*Piper nigrum*) waste will be procured.

***In vitro* study**

These feeds/ byproducts will be tested *in vitro* using the *in vitro* gas production technique (IVGPT) as described by Menke and Steingass, (1988) to estimate the ME and digestible organic matter (DOM) of the feed. The IVGPT will also be adopted to estimate the *in vitro* degradable nitrogen (IVDN) content in the feeds (Raab *et al*., 1983). The crude protein (CP) content of all the above feeds will be determined by standard procedure (AOAC 2016). All the four parameters so analysed will be graded as given below, for each unconventional feed/ byproduct and the best feed/ byproduct shall be selected based on the aggregate score, as follows:

Parameter tested *in vitro*	Unit (on DM basis)	Range of value	Score
CP	Per cent	0-2.5	0
		2.5-5	+
		5-7.5	++
		7.5-10	+++
		10-12.5	++++
		12.5-15	+++++
		>15	++++++
ME	MJ/ kg DM	<4	0
		4-5	+
		5-6	++
		6-7	+++
		7-8	++++
		8-9	+++++
		>9	++++++
DOM	Per cent	<40%	0
		40-50	+
		50-60	++
		60-70	+++
		70-80	++++
		80-90	+++++
		>90%	++++++
IVDN as per cent of total nitrogen	Per cent	<40%	0
		40-50	++++
		50-60	+++++
		60-70	++++++
		70-80	+++
		80-90	++
		>90%	+

Feeding trial

Twelve crossbred dairy cows yielding approximately 10 kg of milk per day and in early lactation will be selected from the Cattle Breeding Farm (CBF), Thumburmuzhi. They will be divided into two groups of six animals each, as uniformly as possible with regard to age, parity, milk yield and body weight.

The experimental animals will be fed with the respective isonitrogenous and isocaloric rations, T_1 and T_2, so as to meet their nutrient requirements as per ICAR (2013). The animals will be maintained under uniform management conditions prevailing in the farm for a period of 90 days. The experimental rations will be formulated as follows:

Experimental ration	Protein source
T_1	Complete ration containing 12 to 13 per cent CP and 64 to 65 per cent TDN, on DM basis
T_2	1/3rd of CP in T1 replaced with CP from the selected unconventional feed/ byproduct from *in vitro* study, on DM basis

Data on daily feed intake and daily milk production will be recorded. The body weight of the animals will be recorded fortnightly.

Morning and evening milk samples will be collected from individual animals every fortnight and analysed for total solids, solids not fat (SNF), protein (AOAC, 2016), fat (IS: 1224, 1977) and milk urea nitrogen (Bector et *al.* 1998). Off odour if any will be noted. From the above data, the milk protein yield and fat yield will be calculated.

Blood samples will be collected at beginning and end of the feeding trial to estimate blood urea nitrogen (Modified Berthlot method, using the available standard kits), glucose (GOP-PAP methodology), calcium (modified OCPC method) and phosphorus (Phosphomolybdate method), using standard kits.

A digestion trial of five days duration will be conducted towards the end of the feeding trial by total collection method. Proximate principles of feed and dung as well as the content of the minerals, in the two rations will be determined as per standard procedure (AOAC, 2016).

Rumen fermentation parameters such as pH, total volatile fatty acid (TVFA) (Barnett and Reid, 1957) and rumen ammonia nitrogen (Beecher and Whitten, 1970) will be estimated. The IVDN content in the rations, expressed as a percentage of the total nitrogen (N) will also be determined (Raab *et al*., 1983). The *in vitro* total gas production from the two complete rations will also be determined (Menke and Steingass, 1988) to estimate the *in vitro* ME and *in vitro* DOM values.

Data on various parameters, from the *in vitro* study and feeding trial will be analysed statistically (Snedecor and Cochran, 1994). Cost of feed per kilogram of milk produced will be worked out.

9. Main items of observation

1. CP of unconventional feeds/ byproducts (%)
2. ME of unconventional feeds/ byproducts (MJ/kg DM)
3. DOM of unconventional feeds/ byproducts (%)
4. IVDN of unconventional feeds/ byproducts, as a percentage of total N
5. Daily dry matter intake (kg)
6. Daily milk production (kg)
7. Body weight at fortnightly intervals (kg)

8. Fortnightly milk fat (g%)
9. Fortnightly SNF in milk (g%)
10. Fortnightly milk protein (g%)
11. Fortnightly total solids in milk (g%)
12. Fortnightly milk urea nitrogen (mg%)
13. Off flavour in milk, if any
14. Rumen fermentation characteristics such as pH, TVFA (meq/l), rumen ammonia (mg/100ml) and *in vitro* total gas production (ml)
15. Blood parameters such as blood urea nitrogen (BUN) in blood and glucose, calcium and phosphorus in plasma (mg%)
16. Proximate composition of feed and dung samples (%)

10. Facilities

a. Existing: Facilities available in the Department of Animal Nutrition, Central Instrumentation Laboratory, CVAS, Pookode and CBF, Thumburmuzhi, will be utilised for the study.

b. Additional facilities required: Nil

11. Duration of study

Four semesters

12. Financial estimate (in Rupees)

Cost of reagents and chemicals --15,000

Contingencies -- 10,000

Total -- 25,000

Signature of the student

Signature of the major advisor

Place: Pookode

Date: 26-07-2017

Name and signature of the members of the advisory committee

Chairman

1. Dr. Biju Chacko
Assistant Professor and Head (I/C)
Department of Animal Nutrition,
College of Veterinary and Animal Sciences, Pookode, Wayanad-673576

Members

1. Dr. S. Senthil Murugan
Assistant Professor,
Department of Animal Nutrition,
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2. Dr. Surej Joseph Bunglavan
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3. Dr. Prasad. A
Assistant Professor
Department of Livestock Production Management
College of Veterinary and Animal Sciences, Mannuthy, Thrissur-680651

Appendix I

References:

AOAC. 2016. Official Methods of Analysis (19th Ed.). Association of Official Analytical Chemistry Washington, D. C. pp 24-77.

Barnett, A. J. G. and Reid, R. L. 1957. Studies on the production of volatile fatty acids from grass by rumen liquor in an artificial rumen. 1. The volatile fatty acid production from fresh grass. *J. Agri. Sci. Camb.* **48**: 315-321.

Bector, B.S., Ram, M. and Sighal, O.P. 1998. Rapid platform test for detection of added urea in milk. *Indian Dairyman*. **50**(4): 59-62.

Beecher, G.P. and Whitten, B.K. 1970. Ammonia determination: Reagent modification and interfering compounds. Analyt. Biochem. 36: 243.

Boguhn, J., Kluth, H., Bulang, M., Engelhard, T. and Rodehutscord, M. 2010. Effects of pressed beet pulp silage inclusion in maize-based rations on performance of high-yielding dairy cows and parameters of rumen fermentation. *Animal.* **4**(1): 30-39.

Chacko, B. 2015. Evaluation of complete feeds with varying levels of neutral detergent fiber for lactating dairy cows. *PhD Thesis*. Kerala Veterinary and Animal Sciences University. College of Veterinary and Animal Sciences, Mannuthy, 250 p.

Chacko, B., Mohan, S. K. M., Ally, K., Shyama, K., Anil, K.S. and Sathian, C. T. 2016. Production performance of cows reared on complete feeds with varying levels of neutral detergent fibre (NDF) as against the conventional grass - concentrate feeding system in Kerala. *J. Vet . Anim. Sci.* **47**(1): 36-41.

ICAR. 2013. *Nutrient requirements of Animals – Cattle and Buffalo.* (3rd Ed.). Indian Council of Agricultural Research, New Delhi. p. 24.

IS: 1224. 1977. *Determination of fat by Gerber's method*. Part I. Milk (1st revision). Indian Standards Institution. New Delhi, p. 18.

Menke, K.H. and Steingass, H. 1988. Estimation of the energetic feed value obtained from chemical analysis and gas production using rumen fluid. *Anim. Res. Dev.* **28**: 7-55.

Raab, L., Cafantaris, B., Jilg, T. and Menke, K.H. 1983. Rumen protein degradation and biosynthesis. A new method for determination of protein degradation in rumen fluid in vitro. *Br. J. Nutr.* **50**:569-582.

Rathinavelu, R. and Graziosi, G. 2005. Potential alternative use of coffee waste and by-products. International Coffee Organization, 1967-05 pp: 1-2.

Snedecor, G.W. and Cochran, W.G. 1994. *Statistical Methods*. (8th Ed.). The Iowa State University Press, Ames, IA. 314p.

Wanapat, M., Puramongkon, P. and Siphuak, W. 2000. Feeding of cassava hay for lactating dairy cows. *J. Asian-Aus. Anim. Sci.* **13**(4): 478.

Xu, C., Cai, Y., Moriya, N., Hosoda, K. and Matsuyama, H. 2008. The effect of replacing brewer's grains with barley tea grounds in total mixed ration silage on feed intake, digestibility and Ruminal fermentation in wethers. *J. Anim. Sci.* **79**: 226-239.

Zebeli, Q., Dijkstra, J., Tafaj, M., Steingass, H., Ametaj, B.N. and Drochner, W. 2008. Modelling the adequacy of dietary fibre in dairy cows based on the responses of ruminal pH and milk fat production to the composition of the diet. *J. Dairy Sci.* **91**(5): 2046 – 2066.

Appendix II

Time frame of work

Semester I

1. Planning of the programme for research.
2. Collection of literature
3. Preparation of synopsis

Semester II

1. Collecting literature
2. Conducting laboratory tests

Semester II

1. Starting research work
2. Collection of data

Semester IV

1. Statistical analysis of data
2. Preparation of thesis
3. Submission of thesis.

CERTIFICATE

Certified that the research project has been formulated observing the stipulations laid down under the prevention of cruelty to animals act (amendment, 1998).

Pookode Dr. Biju Chacko

Date: 24-07-2017. Major Advisor