# EFFECT OF UREA AS A SOURCE OF RUMEN DEGRADABLE PROTEIN ON MILK PRODUCTION OF CROSSBRED COWS IN EARLY LACTATION

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Thesis submitted in partial fulfilment of the requirement for the degree of

## Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University, Thrissur

2005

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# DECLARATION

I hereby declare that the thesis, entitled **"EFFECT OF UREA AS A SOURCE OF RUMEN DEGRADABLE PROTEIN ON MILK PRODUCTION OF CROSSBRED COWS IN EARLY LACTATION"** 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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# CERTIFICATE

Certified that the thesis entitled **"EFFECT OF UREA AS A SOURCE OF RUMEN DEGRADABLE PROTEIN ON MILK PRODUCTION OF CROSSBRED COWS IN EARLY LACTATION"** is a record of research work done independently by **Sheena Joseph,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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## *ACKNOWLEDGEMENTS*

*With great respect, I place on record my most sincere and heartfelt gratitude to the Chairperson of the Advisory Committee, Dr. Ally, K. Assistant Professor, Department of Animal Nutrition, for her meticulous guidance, valuable suggestions, personal attention and whole-hearted support rendered in all possible ways, which was the major factor that led me to accomplish this task.*

*I humbly place my gratitude to Dr. T.V. Viswanathan, Associate Professor and Head, Department of Animal Nutrition and member of Advisory Committee for his inspiring professional guidance, genuine support and timely help rendered to me for the completion of my work.*

*I am indebted to Dr. P. Gangadevi, as a member of the Advisory Committee and wish to put on record my sincere thanks to her for the valuable suggestions, constant encouragement and help rendered during the entire period of research work.*

*I am cordially obliged to Dr. C.T. Sathian, Assistant Professor, Department of Dairy Science and a member of Advisory Committee for his helpful suggestions and co-operation rendered from time to time.*

*I am extremely thankful to Dr. A.D. Mercy, Associate Professor, Department of Animal nutrition, for her unstinted support, valuable help, expert advice, constructive criticism, suggestions and keen interest shown at every stage of this research work.*

*I owe my sincere gratitude to Dr. Shyam Mohan K. M., Assistant Professor, Department of Animal Nutrition, for his valuable suggestions and timely help extended throughout the course of study.*

*My sincere thanks are due to Dr. Shyama K., Assistant Professor, Department of Animal Nutrition, for her personal care and encouragement rendered through out the course of study.*

*I am grateful to Dr. M.R. Rajan, Associate Professor and Head, University Pig Breeding Farm, Mannuthy, for granting permission to use the feed mill.*

*I am thankful for the wholehearted help rendered for statistical analysis of data by Smt. Sujatha, Assistant Professor and Head, Depatment of Statistics.*

*I gratefully acknowledge Mr. Chandrasekharan, Associate Professor and Instrumentation Engineer, Mrs. Dhanya, Research Assistant, Central Instrumentation Laboratory for their timely help and cooperation.*

*I am in short of words to express my deep sense of gratitude to my colleagues Drs. Raja, Mary, Smitha N.F and Smitha Wilson, without whose tireless help, unconditional support and constant encouragement the successful completion of this research work would not have been possible.*

*I sincerely thank Dr. Anup and Dr. Jith and other seniors Dr. Suresh and Dr. Sekar for the timely help and support rendered. The help given by Dr. Senthil, Ph.D Scholar and junior colleagues Drs. Harish, Smitha and Jasmin is greatly acknowledged. I take great pleasure in thanking Drs. Anu, Asha, Dhanya, Jaibi, Nisa, Praveena and Anu Mathew and all other friends of my batch for their lots of help, friendliness, co-operation and moral support.*

*I take this opportunity to express my thanks to all the non teaching staff in the Department of Animal Nutrition who have helped me a lot in the successful completion of the work. I remember and acknowledge staff and labourers of university livestock farm, Mannuthy and all others who have helped to carry out the research work.*

*I thank the Dean, Faculty of Veterinary and Animal Sciences for providing the facilities for the study. I am indebted to Kerala Agricultural University for awarding me the fellowship for the postgraduate study.*

*I am in short of words to express my deep sense of love and gratitude to my beloved Pappa and brother Shibu.*

*Above all, I adore and thank my eternal father* ***The Holy Trinity****, for all the blessings showered upon me and venerate my heavenly mother* ***Holy Mary and St. Joseph*** *for their love, care and protection.*

*Sheena Joseph*

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# *Introduction*

# 1. INTRODUCTION

Feeding of dairy cattle becomes more and more complicated each year due to an ever increasing level of milk production. Among the various nutrients, protein forms the most significant and costliest constituent of the dairy ration. Hence both the quantity and quality of protein are very important in dairy rations.

High producing cows have an increased demand for protein in the form of amino acids, which is achieved by intestinal absorption of amino acids from dietary, microbial and endogenous proteins. Microbes can provide sufficient protein for maintenance, slow growth and early gestation, but cannot meet increased demand for high milk production. To achieve the greater flow of amino acids to the small intestine, dietary protein must escape ruminal degradation without decreasing the efficiency of synthesis of microbial protein. An excess of rumen degradable protein (RDP) in the ration will result in an accumulation of ammonia in the rumen which will be absorbed, converted to urea for which energy is required, overtaxing the already energy deficient cow. The increase in undegradable protein (UDP) levels in the ration will reduce the microbial protein synthesis due to shortage of ammonia for rumen bacteria. The dietary protein should supply metabolizable protein by providing both RDP that is utilized for microbial protein synthesis and UDP that is digested directly by the cows.

Protein feeds are scarce and expensive, especially in the developing countries. Non protein nitrogen (NPN) is a cheaper source of protein and is equally good as preformed protein and increases the microbial protein flow to the intestine. Urea is the cheapest and most commonly used NPN source, which is degraded completely in the rumen. The ammonia liberated being trapped by rumen microorganisms for their protein synthesis. So a combination of UDP and NPN substance like urea can be equally effective and economical in dairy rations.

Various studies have shown that feeding of UDP sources at various levels improved the production performance of medium and high producing animals. The crossbred cows with 10 kg peak yield, fed 17 per cent CP concentrate mixture with 40 per cent UDP showed a marginal increase in production compared to those fed 25 per cent UDP (Ally, 2003). The present study was undertaken to ascertain whether inclusion of a readily degradable protein source like urea will influence the production response of crossbred cows in early lactation with 10 kg peak yield to higher levels CP and UDP in the ration.

# *Review of Literature*

# 2. REVIEW OF LITERATURE

Dairy cows in early lactation will be in negative energy balance as the dry matter intake will not be sufficient to meet the requirements especially during the first few months of lactation. Therefore the ration given during this period should be of good quality in order to have maximum efficiency of production. The level of protein in the ration, its degradability and as well as the source play a critical role in the efficiency of utilization of energy during early lactation (Clark and Davis, 1980).

## 2.1 EFFECT OF LEVEL OF PROTEIN IN EARLY LACTATION

### 2.1.1. Effect on Dry Matter Intake and Body Weight

There are numerous research reports stating that dry matter intake (DMI) of dairy cows in early lactation increased with an increase in dietary crude protein (CP) levels. Claypool *et al.* (1980) with rations having 13,16 and 19 per cent CP, Barney *et al.* (1981) with rations having 13 and 17 per cent CP, Roffler and Thacker (1983) with rations having 16.5 and 13.5 per cent CP, Macleod *et al.* (1984) with rations having 12, 15 and 18 per cent CP and Broderick (2003) with rations having 15.1, 16.7 and 18.4 per cent CP reported an increase in DMI corresponding to an increase in CP in the ration.

Cressman *et al.* (1980) reported a lack of influence on DMI by difference in the level of dietary CP when 12, 15 and 18 per cent CP rations were given to early lactating dairy cows. Similar lack of influence of protein levels on DMI were reported by Jordhan *et al.* (1983), Howard *et* al (1987), Leonard and Block (1988) and Noftsger and St- Pierre (2003). Henderson *et al.* (1985) observed that DMI was not affected by dietary CP levels or source of protein added in the ration. Ally (2003) reported that there was no significant difference in DMI when cows were fed rations with 13.2 and 15.4 per cent CP.

A reduction in DMI was observed by Baxter *et al.* (1983) for 15 and 17 per cent CP rations compared with 12.8 per cent CP ration. Similarly, Ally (2003) reported a reduction in DMI by cows receiving 20 per cent CP ration compared with 15.4 and 13.2 per cent CP rations in early lactation.

Edwards *et al.* (1980) found a lack of influence of dietary CP levels (13, 15 and 17 per cent) on body weight changes in early lactation. Similar result was reported by Baxter *et al.* (1983), Leonard and Block *et al.* (1988), Cunningham *et al.* (1996), Ally (2003) and Noftsger and St- Pierre (2003). Roffler and Thacker (1983) found that cows fed 16.5 per cent CP ration weighed more at 12 week post partum than those fed 13.5 per cent CP ration. Ha and Kennely (1984) observed that cows fed 13.5 per cent CP ration lost 0.43 kg per day where as those at 15,17 and 19 gained 0.59, 0.38 and 0.59 kg per day in early lactation. Howard *et al.* (1987) reported that cows fed 15 per cent CP ration lost more weight than those fed 20 per cent CP ration.

**2.1.2 Effect on Milk Production**

Feeding diets sufficiently high in CP for maximum milk production may not be always profitable. Increasing the CP content of the ration should be considered only when cost of the additional CP is less than the returns from additional milk (Clark and Davis, 1980). They also opined that grams of CP consumed daily is more closely correlated with milk yield than the level of CP in the ration.

The response of dairy cows in milk production to the level of CP in the ration has been conflicting. A CP level of 15 per cent in the ration for cows producing 28 to 29 kg was recommended by Edwards *et al.* (1980) and Ha and Kennely (1984) while a higher level of 19 to 20 per cent was suggested by Blauwiekel and Kincaid (1986) and Howard *et al.* (1987). Broderick (2003) reported that regardless of dietary energy content, feeding 16.7 per cent CP was adequate for supporting the milk production in dairy cows with an average yield of 34 kg per day. As per NRC (1971) a CP level of 13 to 14 per cent of dry matter of a complete ration is sufficient to meet the requirement of lactating cows unless the production is too high. Bureau of Indian Standards (BIS, 1992) has specified a CP level of 22 and 20 for grade 1 and II compounded feed for dairy cattle.

A decrease in milk production with increase in CP level above 14 per cent in the dairy rations was reported by Kwan *et al.* (1977) whereas an increase in the production by increasing the CP level of ration above 14 per cent was reported by many scientists (Claypool *et al.*, 1980 with 13,16 and 19 per cent CP rations; Cressman *et al.*, 1980 with 12,15 and 18 per cent CP rations; Zimmerman *et al.*, 1991 with 14,18 and 22 CP per cent rations; Cunningham *et al.*, 1996 with 14.5,16.5 and 18.5 CP per cent rations; Broderick, 2003 with 15.1,16.7 and18.4 per cent CP rations).

Various research workers have indicated that milk production by cows in early lactation was not affected by the level of protein in the ration. Henderson *et al.* (1985), Leonard and Block (1988), McCormick *et al.* (1999), Bach *et al.* (2000), Castillo *et al.* (2001), Sannes *et al.* (2002), Ally (2003), Davidson *et al.* (2003) and Noftsger and St- Pierre (2003) made this observation by using rations with CP levels ranging from 15.0 to 23.1 per cent in different experiments conducted in early lactation.

The response of level of protein varies with parity. Cressman *et al.* (1980) reported that multiparous cows produced more milk than primiparous cows when fed 18 per cent CP than 12 per cent ration. In contrast, Roffler and Thacker (1983) opined that there was no interaction between parity and concentration of dietary CP on milk yield. Khorasani *et al.* (1994) also observed that milk yield was greater for multiparous cows than primiparous cows in early lactation, when fed isonitrogenous rations with 18.2 per cent CP that differed in sources of protein and starch.

Source of protein also influence the response to added dietary CP during early lactation. Roffler and Thacker (1983) observed lesser response in milk yield from added cottonseed meal (CSM) than soybean meal (SBM). O'Mara *et al.* (1998) found that ration supplemented with fish meal (FM) increased the production performance when compared to SBM. Sohane *et al.* (1997) opined that if all other nutrients are supplied in adequate amounts, the magnitude of response in milk yield to additional protein will depend on amount and type of protein in the basal ration as well as genetic ability of cow.

Claypool *et al.* (1980) reported that milk composition was not affected by rations with different CP levels (13, 16 and 19 per cent) in early lactation. Similar observations were also made by Barney *et al.* (1981), Sannes *et al.* (2002), Davidson *et al.* (2003) and Ally (2003) using rations ranging from 13.2 to 20 per cent CP. Edwards *et al.* (1980) found that solids not fat (SNF) was lower for milk from cows fed 13 per cent CP ration compared to those fed 15 or 17 per cent CP ration where as milk fat per cent and milk protein were not affected by protein concentration in the ration.

Various studies have shown that feeding high levels of dietary CP can partially alleviate the problem of milk fat depression caused by feeding low fibre rations having CP levels ranging from 12.8 to 22 per cent (Baxter, *et al.*, 1983; Jaquette, *et al.*, 1987; Leonard and Block, 1988). Cunningham *et al.* (1996) observed an increase in yield of fat as the dietary CP level increased from 14.5 to 18.5 per cent in early lactation.

Forster *et al.* (1983) and Henderson *et al.* (1985) reported a linear increase in both milk protein and fat levels in response to increase in dietary CP levels from 16 to 22 per cent. Ha and Kennely (1984) found that concentration of milk protein was higher for milk from the cows on 15 per cent CP than those on 13, 17 and 19 per cent CP. Macleod *et al.* (1984) reported that yields of milk fat increased linearly and yields of protein and lactose increased curvilinearly in response to increased dietary protein from 12 to 18 per cent. Zimmerman *et al.*

(1991) observed an increase in yield of fat, protein and SNF when cows fed with 18 and 22 per cent CP rations compared to those fed 14 per cent CP ration. Bach *et al.*, (2000) reported that within each level of protein consumption (15 and 18 per cent), a high quality amino acid profile tended to increase milk protein and milk fat content. The increase in milk protein concentration was more with 15 per cent CP ration whereas milk fat content was greater with high quality 18 per cent ration.

Korhonen *et al.* (2002) reported that 17 per cent CP ration supplemented with SBM, FM or corn gluten meal (CGM) had increased milk protein and lactose yield but did not affect yield of milk fat compared to those fed 13.4 per cent CP ration.

Roffler and Thacker (1983) and Howard *et al.* (1987) found that there was no relation between dietary CP level and concentration of protein or fat in milk. Christensen *et al.* (1993a) observed that milk protein and SNF percentages were unaffected by the amount of protein in the ration (16.4 and 19.6 per cent).

Roseler *et al.* (1993) observed that milk urea nitrogen (MUN) expressed as per cent of total milk non protein nitrogen increased from 20 to 45 per cent as the dietary CP levels increased from12.2 to 17.2 per cent of dry matter. Bach *et al.* (2000) reported a linear increase in MUN concentration corresponding to an increase in ration CP from 15 to 18 per cent. Similar observations were also made by Kauffman and St-Pierre (2001) with13 and 17 per cent CP rations, Noftsger and St- Pierre (2003) with 17 and 18.3 per cent CP rations and Broderick (2003) with 15.1, 16.7 and18.4 per cent CP rations. Nousiainen *et al.* (2004) stated that dietary CP content is the most important nutritional factor influencing MUN and measurement of MUN can be used as diagnostic of protein feeding.

Oltner and Wiktorsson (1983) opined that main factor influencing milk urea nitrogen (MUN) was not the amount of protein ingested, but the relationship between protein and energy in the ration. Oltner *et al.* (1985) and Jonker *et al.* (1998) reported that MUN levels showed a positive correlation to the measures of ration composition and to the milk yield where it was negatively correlated with the body weight changes. Arunvipas *et al.* (2003) also reported the positive relationship between MUN concentration and milk yield while there was a negative correlation with dietary CP level. Yoon *et al.* (2004) observed that MUN levels had a positive correlation with milk yield and fat content.

### 2.1.3 Effect on Rumen Fermentation Parameters and Haematological Parameters

Claypool *et al.* (1980) observed that there was no significant difference in the rumen pH of dairy cows fed 13, 16 and 19 per cent CP rations. Similar observations were also made by various research workers (Cressman *et al.*, 1980; Ha and Kennely, 1984; Annextad *et al.*, 1987; Sannes *et al.*, 2002).

The effect of protein concentration in the ration on rumen ammonia nitrogen ($NH_3$-N) has been studied by many research workers. A linear response to $NH_3$–N with increase in the protein concentration using the rations having CP levels ranging between 11.7 to 22 per cent was reported by various scientists (Kwan *et al.*, 1977; Cressman *et al.*, 1980; Ha and Kennely, 1984; Leonard and Block, 1988; Zimmerman *et al.*, 1991; Christensen *et al.*, 1993b; Sannes *et al.*, 2002; Davidson *et al.*, 2003). Ha and Kennely (1984) found that each percentage unit increase of dietary CP elevated ruminal $NH_3$–N concentration by approximately 1.5 mg per 100 ml of rumen fluid.

Total volatile fatty acids (TVFA) and acetate to propionate ratio were not affected significantly by protein concentration in the ration (Cressman *et al.*, 1980; Ha and Kennely, 1984; Zimmerman *et al.*, 1991; Korhonen *et al.*, 2002; Davidson *et al.*, 2003). Cressman *et al.*, 1980 observed an increase in butyrate concentration in the rumen fluid in response to increase in CP levels from 12 to 18 per cent. Sannes *et al.* (2002) reported that even though the TVFA level was not affected by the dietary CP levels, the proportion of total branched chain fatty acids levels was more in the 18 and 19.6 per cent CP rations compared to 17 per cent ration.

Jordan *et al.* (1983) and Blauwiekel and Kincaid (1986) reported that amount or source of protein in the ration had no effect on plasma glucose level (PGL) in early lactation. Jaquette *et al.* (1987) observed that blood glucose level (BGL) was 51 to 64 mg per dl during the first four weeks of lactation when cows fed 14 and 22 per cent CP ration. Bach *et al.* (2000) found that BGL was numerically higher for cows fed 15 per cent CP ration than those fed 18 per cent CP, though the values did not differ significantly. Similarly, Korhonen *et al.* (2002) reported a decrease in BGL as the CP level increased from 13.4 to 17 per cent in the ration.

Jordhan *et al.* (1983) found that concentration of calcium in the plasma did not differ with protein level in the ration (12 and 23 per cent CP) and plasma phosphorus was higher in cows fed 23 per cent CP ration compared with cows fed the 12 per cent CP ration.

Claypool *et al.* (1980), Jordhan *et al.* (1983) and Blauwiekel and Kincaid (1986) observed no significant effect of dietary CP levels ranging from 12 to 23 per cent on serum albumin concentration. Cressman *et al.* (1980) observed that total protein of plasma was increased from 7.89 mg per dl to 8.84 mg per dl as protein levels in the ration increased 12 per cent to 18 per cent. Tomlinson *et al.* (1994) reported that total protein was affected by source of protein and was significantly higher in blood meal diets than those fed SBM diets in both 15 and 18 per cent CP rations.

Cressman *et al.* (1980) reported a significant increase in blood urea nitrogen (BUN) levels from 4.59 mg per dl to 21.73 mg per dl when CP level in the ration increased from 12 to 18 per cent. Plasma urea nitrogen (PUN) was elevated in response to increased CP levels in the ration as observed by Claypool *et al.* (1980), Jordhan *et al.* (1983), Macleod *et al.* (1984), Ha and Kennely (1984), Jaquette *et al.* (1987), Zimmerman *et al.* (1991), Roseler *et al.* (1993), Bach *et al.* (2000), Kauffman and St-Pierre (2001), Davidson *et al.* (2003) and Noftsger and St- Pierre (2003). Howard *et al.* (1987) observed that concentration of PUN increased rapidly during the first four weeks of lactation in cows fed on 20 per cent CP ration and after fifth week of experiment, concentration of PUN was relatively constant for cows fed on both 15 and 20 per cent CP rations..

Korhonen *et al.* (2002) recorded that protein supplements increased PUN concentration which was higher with 17 per cent CP ration containing SBM as source of protein compared to CGM ration (17 per cent CP).

## 2.2 EFFECT OF UREA AS SOURCE OF NON PROTEIN NITROGEN IN EARLY LACTATION

It has been known for almost a century that microorganisms in the rumen have the unique ability to convert non protein nitrogen (NPN) to protein. Urea has been the most widely used and cheapest NPN compound in the ruminant ration (Helmer and Bartley, 1971).

### 2.2.1 Effect as source of rumen degradable protein (RDP)

The use of undegradable protein in the rations of high producing cows is often associated with the use of readily available NPN sources like urea. Wiley *et al.* (1991) reported that urea can be used as RDP source without affecting the production performance in primiparous cows. Windschitl (1991) observed that there was no significant difference in the milk production when cows fed 20 per cent CP concentrate mixtures containing SBM or salmon meal plus urea as protein supplements with RDP levels 72.2, 64.4 and 67.6 per cent respectively. Sannes *et al.* (2002) reported that urea added as a source of RDP in 18.5 CP ration was effective in maintaining the milk yield, dry matter intake and microbial protein synthesis in early lactation.

Cabrita *et al.* (2003) evaluated the effects of different proportions of quickly and slowly degradable protein achieved by replacing the SBM with urea in the concentrates (0, 0.5, and 1.0 per cent urea) and found that there were no significant treatment effects on DMI, milk yield or composition.

### 2.2.2 Effect on Dry Matter Intake and Body Weight

Loosli and Warner (1958) reported that concentrate mixture containing more than three per cent urea were consumed more slowly with reluctance by high yielding cows. Addition of urea as source of nitrogen to the dairy rations depressed the DMI in early lactation (Van Horn *et al.*, 1967; Jones *et al.*, 1975; Erb *et al.*, 1976).

Huber *et al.* (1967) reported that dry matter intake by the cows was not affected by supplementation of urea, which furnished 48 and 38 per cent of total ration nitrogen. Many research workers reported similar lack of influence of supplementation of urea ranging from 0.15 to 3.0 per cent in the concentrate mixture (Martz *et al.*, 1971; Razdan *et al.*, 1971; Plummer *et al.*, 1971; Clark *et al.*, 1973; Grieve *et al.*, 1973; Kwan *et al.*, 1977; Colenbrander *et al.*, 1983; Casper *et al.*, 1990; Broderick *et al.*, 1993; Christensen *et al.*, 1993a; Lines and Weiss, 1996; Sannes *et al.*, 2000; Galo *et al.*, 2003).

Van horn *et al.* (1967) found that feeding of concentrate mixture containing 2.2 and 2.7 per cent urea markedly decreased the body weight. Similar observation was made by Huber *et al.* (1967) when 48 per cent of dietary nitrogen was furnished by urea. Martz *et al.* (1971), Plummer *et al.* (1971) and Davidson *et al.* (2003) observed that inclusion of urea at the levels ranging from 0.4 to 3.1 per cent in the concentrate mixture in different experiments did not significantly affect the body weight changes of dairy cows in early lactation. Jones *et al.* (1975) observed that cows fed SBM had greater body weight gain than those fed urea or starea rations. Similarly, Casper *et al.* (1990) and Broderick *et al.* (1993) observed that cows given diets containing true protein had better weight gain compared to those fed diets containing urea as nitrogen source.

**2.2.3 Effect on Milk Production**

Loosli and Warner (1958) reported that when urea was added at a level of three per cent in the concentrate mixture for high yielding cows, milk yield was decreased in early lactation. Colovos *et al.* (1967a) also observed a reduction in milk yield when 16 per cent CP concentrate mixture containing two per cent urea was given to cows producing 20 to 23 kg milk per day. This agrees with the reports of Huber *et al.* (1967) where urea furnished 38 and 48 per cent of dietary nitrogen in corn silage based rations in early lactation.

Various studies have shown that there was no significant difference in the milk production of high yielding cows when different levels of urea (1.25 to 3 per cent) were added to the concentrate mixture to replace 16 to 35 per cent of plant protein nitrogen in early lactation (Colovos *et al.*, 1967b; Van horn *et al.*, 1967; Plummer *et al.*, 1971; Clark *et al.*, 1973; Colenbrander *et al.*, 1983). Jones *et al.* (1975) found that milk yield was higher for cows fed 15.5 CP ration supplemented with SBM alone as protein source than those fed rations of same CP in which 16 and 22 per cent of total nitrogen were provided by urea and starea, respectively. Crish *et al.* (1986) reported that addition of SBM to the basal ration to increase the protein concentration to 15 per cent increased the milk production when compared to those fed urea supplemented ration. In contrast, Casper and Schingoethe (1986) observed that milk yield was similar when 16 per cent CP concentrate mixtures supplied with either urea (one per cent) or SBM.

Casper *et al.* (1990) reported that there was no difference in the milk yield between cows fed rations with 16 per cent CP concentrate mixtures containing SBM or one per cent urea in early lactation. Similar lack of effect of dietary urea on milk production was reported by Broderick *et al.* (1993), Christensen *et al.* (1993a), Lines and Weiss (1996), Davidson *et al.* (2003) and Cabrita *et al.* (2003) when fed rations containing 0.15 to 1.8 per cent urea in early lactation.

Srinivas and Gupta (1996) reported that urea-molasses-mineral block could substitute 10 per cent of the concentrate requirement without affecting milk yield of crossbred cows producing 14 kg milk per day when they were fed 15 percent CP ration.

Many research workers did not observe any significant effect of inclusion of urea to dairy rations on milk fat per cent in early lactation (Loosli and Warner, 1958; Huber *et al.*, 1967; Martz *et al.*, 1971; Clark *et al.*, 1973; Kwan *et al.*, 1977; Colenbrander *et al.*, 1983; Broderick *et al.*, 1993; Davidson *et al.*, 2000; Galo *et al.*, 2003). Colovos *et al.* (1967a) and Plummer *et al.* (1971) observed an increase in milk fat per cent when urea was added at the levels of two per cent to 16 per cent CP concentrate mixture. Casper and Schingoethe (1986) reported a decrease in milk fat percent when cows fed rations supplemented with one per cent urea than those supplemented with SBM.

Huber *et al.* (1967) and Jones *et al.* (1975) observed that milk protein and SNF lowered significantly when rations supplemented with urea while many scientists reported that urea supplementation had no significant effect on milk protein per cent in early lactation (Clark *et al.*, 1973; Kwan *et al.*, 1977; Casper and Schingoethe, 1986; Sannes *et al.*, 2002; Davidson *et al.*, 2003; Galo *et al.*, 2003). There was no significant effect of urea supplementation on milk composition as reported by Sannes *et al.* (2002), Davidson *et al.* (2003), Cabrita *et al.* (2003) and Galo *et al.* (2003).

Galo *et al.* (2003) reported that coated urea, slowly hydrolyzed to ammonia in rumen, increased MUN concentration when CP content in the ration increased from 16 to 18 per cent in early lactation.

### 2.2.4 Effect on Rumen Fermentation Parameters and Haematological Parameters

Plummer *et al.* (1971) and Santos *et al.* (1984) found that rumen pH was not affected by the addition of urea in corn silage based rations. Schingoethe *et al.* (1976) observed that rumen pH of cows fed urea treated corn silage and urea whey corn silage was lower than that of cows fed hay. Casper *et al.* (1990)

observed that addition of urea did not affect the rumen pH when lactating animals fed rations containing two sources of nonstructural carbohydrates. Cameron *et al.* (1991) also observed a decrease in rumen pH by addition of 0.75 per cent urea to the rations. Cunningham *et al.* (1996) observed that rumen pH was similar in cows fed 14.5, 16.5 and 18.5 per cent CP rations containing 0.42 per cent urea. Similar findings have been reported by Meng *et al.* (2000) and Sannes *et al.* (2002).

Colovos *et al.* (1967a) observed a significant increase in the proportion of acetic acid at the expense of butyric acid in the rumen fluid, two hours after feeding when cows fed concentrate mixture containing two per cent urea. Plummer *et al.* (1971) found that when urea was added at different levels of two or three per cent to the concentrate mixture, the acetic acid proportion increased and propionic acid level was decreased. An increase in the levels of TVFA and propionic acid concentration corresponding to level of inclusion of urea in the ration were reported by Schingoethe *et al.* (1976), Casper and Schingoethe (1986) and Christensen *et al.* (1993b).

Many research workers reported that addition of urea at different levels in the dairy ration had no significant effect on TVFA concentration (Santos *et al.*, 1984; Casper *et al.*, 1990; Cameron *et al.*, 1991; Windchitl, 1991). Meng *et al.* (2000) reported that the production of TVFA was not significantly different with rations containing varying levels of rumen degradable soy protein formulated by use of corn starch, urea and isolated soy protein. Devant *et al.* (2001) observed that ration containing SBM had the greater TVFA concentration and molar percentages of acetate than rations supplemented with urea.

Colovos *et al.* (1967b) found that rumen ammonia nitrogen concentration was increased with addition of urea in the 17 per cent CP concentrate mixture fed to lactating animals. Similar observations were made by Casper and Schingoethe (1986), Casper (1990), Broderick *et al.* (1993) and Lines and Weiss (1996).

Cameron *et al.* (1991) observed that supplementing the ration with 0.75 per cent urea doubled concentration of $NH_3$–N.

Colovos *et al.* (1967a) observed that BGL in lactating animals was not affected by the addition of urea to the concentrate mixtures. Wiley *et al.* (1991) reported that BGL did not change when cows were fed diets containing 0.98 per cent urea as source of RDP. They also observed that dietary urea had no effect on serum albumin and serum creatinine levels in early lactation.

Huber *et al.* (1967) reported that BUN was numerically higher for cows receiving urea rations, though the difference being nonsignificant. Kwan *et al.* (1977) observed that there was a significant increase in PUN in response to increase in dietary CP levels from 14 to 16.6 per cent when all the rations contained one per cent urea. An increase in PUN in proportion to increase in dietary CP levels was also observed by Wiley *et al.* (1991) and Christensen *et al.* (1993a). Davidson *et al.* (2003) could not find any difference in the PUN level between cows fed 17.2 per cent CP ration containing 0.4 per cent urea (12.6 mg per dl) and 16.8 per cent CP ration without urea (12.4 mg per dl).

Jones *et al.* (1975) and Broderick *et al.* (1993) observed a reduction in PUN level when cows fed true protein supplements than those fed urea containing rations.

## 2.3. EFFECT OF DEGRADABILITY OF PROTEIN IN EARLY LACTATION

In high yielding cows the microbial protein alone cannot meet the nutritional requirements and in such cases a source of rumen undegradable protein (RUP) also should be provided in the ration to meet the requirements (Armentano *et al.*, 1993) and to maintain the total amino acid flow to the small intestine for enhanced milk production (Zimmerman *et al.*, 1992).

### 2.3.1 Effect on Dry Matter Intake and Body Weight

Several workers observed higher feed consumption in lactating cows in response to increase in RUP levels in the ration (Zimmerman *et al.*, 1992, Kalbande and Thomas, 1999; Sannes *et al.*, 2002). Kalbande and Thomas (1999) reported that increasing the level of undegradable protein (UDP) of concentrate mixture from 30 to 63 per cent increased DMI in crossbred cows maintained on low quality roughage and producing about 10 kg milk per day. In contrary to this, Ally (2003) observed a reduction in daily DMI when UDP level of 17 per cent CP ration was increased from 26.8 to 42.9 per cent in early lactation. Flis and Wattiaux (2005) reported an increase in DMI when cows fed 10 per cent excess of RUP than that of NRC recommended level in 18.4 per cent CP ration

Forster *et al.* (1983) did not observe any influence of varying protein degradability levels of 43, 49 and 54 per cent on DMI when isonitrogenous rations (14 per cent) were received by cows in early lactation. Similar observation of uniform feed consumption irrespective of a change in UDP levels in the ration have been reported by many workers (McGuffey *et al.*, 1990; Hoffman *et al.*, 1991; Nianogo *et al.*, 1991; Aharoni *et al.*, 1993; Christensen *et al.*, 1993b; Davidson *et al.*, 2003).

Hoffman *et al.* (1991) reported a nonsignificant effect of UDP levels on body weight changes when cows were fed 18 per cent CP ration with 33 and 36 per cent UDP. Similar observations were made by Zimmerman *et al.* (1991), Triplett *et al.* (1995), Ally (2003) and Davidson *et al.* (2003). In contrast, Nianogo *et al.* (1991) reported that increasing the dietary escape protein resulted in more weight loss when treated SBM and CGM were used as sources of escape protein in the ration. An increase in body weight gain in response to increase in the level of UDP in the ration was observed by Wiley *et al.* (1991) and Son *et al.* (1996).

**2.3.2. Effect on Milk Production**

Efforts to modify the milk yield and composition by increasing the undegradable portion of the protein in the ration by increasing the CP content and its undegradability has resulted in both positive and negative results. A large number of reports indicate that, the increase in dietary UDP level did not affect the milk yield (Erdman and Vandersall, 1983; Hoffman *et al.*, 1991; Nianogo *et al.*, 1991; Christensen. *et al.*, 1993a; Dunlap *et al.*, 2000; Sannes *et al.*, 2002; Davidson *et al.*, 2003). Forster *et al.* (1983) reported that increasing the UDP level from 46 to 57 per cent of 14 per cent CP ration raised the milk yield to 34.2 kg per day from 30.8 kg. McGuffey *et al.* (1990) reported that when cows fed isocaloric rations with high undegradable intake protein (UIP) of 40 per cent CP had greater milk yield compared to that of 33 per cent UIP in both 14 and 17 per cent CP rations. Aharoni *et al.* (1993) observed that feeding of 17 per cent CP rations with UIP of 35 per cent enhanced the milk yield 1.5 kg per day than those fed 30 per cent UIP. Armentano *et al.* (1993) observed an increase in milk production when UDP level of a 16 per cent ration was increased from 26 to 45 per cent. Kalbande (1995) reported that in medium producing crossbred cows on a grass based basal diet, UDP level of 63 percent in 20 per cent CP concentrate mixture resulted in higher milk production compared with UDP levels of 48 and 30 per cent. Similarly, increased milk yield in response to increase in UDP content in the ration was observed by Cunningham *et al.* (1996), McCormick *et al.* (1999), Kanjanapruthapong and Buatong (2002) and Ally (2003).

Multiparous cows were more responsive to higher levels of UDP compared to primiparous cows (Cressman *et al.*, 1980; Roffler and Thacker, 1983; Khorasani *et al.*, 1994). On the contrary, Jaquette *et al.* (1987), Zimmerman *et al.* (1992) and Triplett *et al.* (1995) recorded a higher level of production in primiparous cows supplemented with UDP while no change in the production was observed in multiparous cows fed the same ration.

Winsryg *et al.* (199I) reported that undegradability of protein sources had no influence on milk yield when CGM and meat cum bone meal used as UDP supplements in 14 percent CP ration. Wiley *et al.* (199I) also observed that milk production was unaffected when by use of blood meal or CGM as source of UDP and urea as RDP supplement. Windschitl (1991) also reported that there was no significant difference in milk production when cows fed 20 per cent CP rations containing salmon meal, salmon meal plus urea and SBM as protein sources with UDP levels of 36, 32 and 29 per cent, respectively. Korhonen *et al.* (2002) reported a lower milk production response to SBM than to FM and CGM due to high protein degradability of SBM in 17 percent ration. Broderick *et al.* (2002) reported that 22 per cent CP ration supplemented with expeller SBM as source of RUP increased the milk yield in early lactation compared to rations without expeller SBM. Reynal and Broderick (2003) observed that when 19 per cent CP rations containing either expeller SBM, solvent SBM, blood meal or CGM were given to cows expeller SBM produced more milk than those of other treatments. Flis and Wattiaux (2005) reported that when cows fed excess RUP diets in the form of expeller SBM, milk production increased but the opposite was true when the diets contained excess RDP in the form of solvent SBM.

Aharoni *et al.* (1993) observed that yields of milk protein and fat and fat percentage were higher when degradability of 17 per cent CP ration decreased from 70 to 65 per cent. The increase in milk protein yield and fat yield were 0.055 kg per day and 0.196 kg per day, respectively, in cows producing 35 kg milk per day. Similarly Christensen *et al.* (1993a) reported higher milk fat content and yield in cows receiving 16.4 or 19.4 per cent CP with 55 per cent degradability than those fed same CP ration with 70 per cent degradability. They also observed that milk protein yield and SNF were unaffected by the amount of CP or UDP in the ration. Kalbande (1995) observed that milk fat per cent was not altered with degradability changes but both milk protein and total solids were increased in proportion to increase in UDP levels. Cunningham *et al.* (1996)

reported that yields of milk fat and protein were increased as dietary RUP content increased.

Windschitl (1991) observed that substitution of salmon meal for SBM, which increased UDP from 28.8 to 35.6 per cent, reduced milk fat per cent and yield with no effect on yields of milk protein. The yields of protein, lactose and SNF were increased by supplementing fish meal as source of RUP as reported by Vagoni and Broderick (1997).

Hoffman *et al.* (1991) opined that addition of UIP had no effect on milk yield, milk protein or fat and on milk fatty acid composition. Nianogo *et al.* (1991) reported that per cent composition and yields of milk, SNF, protein and total solids were not influenced by levels of escape protein in the ration. Published work by different authors do not reveal any significant effect of UDP level in the ration on milk composition was reported by various research workers (Zimmerman *et al.*, 1992; Son *et al.*, 1996; Rodriguez *et al.*1997; Sannes *et al.*, 2002; Ally, 2003; Davidson *et al.*, 2003; Reynal and Broderick, 2003; Geerts *et al.*, 2004; Flis and Wattiaux, 2005).

Rodriguez *et al.* (1997) observed an increase in MUN when UDP content of a ration increased from 29 to 41 per cent even though the difference was not significant. Eicher *et al.* (1999) suggested that over feeding of rumen soluble protein can be diagnosed and corrected using MUN analyses. Godden *et al.* (2001) based on data collected over 13 months period from 53 commercial Ontario dairy herds opined that herd mean MUN had a positive relationship with levels of RDP and RUP in the ration. Geerts *et al.* (2004) reported an increase in MUN from 24.7 to 33.1 mg per dl when daily rumen degraded protein balance increased from 150 g to 400 g.

Butler *et al.* (1996) reported that concentrations of MUN greater than 19 mg per dl were associated with a 20 per cent decrease in pregnancy rate. Melendez *et al.* (2000) observed that cows having MUN greater than 19 mg per dl during 0 to 30 days before first service was at 18 times lesser chance for conception.

### 2.3.3 Effect on Rumen Fermentation Parameters and Haematological Parameters

Forster *et al.* (1983) when used three rations with 13, 14 and 17 per cent CP and differing in protein degradability observed a similar rumen pH in the range of 5.78 to 6.49 during 8 weeks postpartum in Holstein cows. Rodriguez *et al.* (1997) reported that the degradability of dietary protein had no effect on rumen pH by using 16 per cent CP ration with 29 and 41 per cent UDP. Similar observations were made by Devant *et al.* (2001), Kanjanapruthipong *et al.* (2002), Ally (2003) and Reynal and Broderick (2003).

Christensen *et al.* (1993a) reported that ruminal pH was not affected by the CP content but was reduced when RUP of ration increased from 30 to 45 per cent without affecting the fibre digestibility. Meng *et al.* (2000) reported that rumen pH was unaffected by the RDP levels in the ration and it increased as the dilution rate increased.

Many workers have reported the effect of protein source and its degradability on TVFA and molar proportions of individual fatty acids. Blauwiekel and Kincaid (1986) observed that cows fed high CP rations (19 per cent) with low nitrogen solubility of 29 per cent had increased acetate to propionate ratio in the rumen fluid compared with 14.4 per cent CP ration. Christensen *et al.* (1993a) recorded lower TVFA concentration with higher RUP levels in the ration (35 percent) and acetate propionate ratio was lower for rations containing low RUP level (30 per cent). Davidson *et al.* (2003), observed that greater amount of degradable protein in the ration resulted in an increase in TVFA concentration.

Annextad *et al.* (1987), Khorasani *et al.* (1994), Rodriguez *et al.* (1997), Meng *et al.* (2000), Sannes *et al.* (2002) and Ally (2003) reported that there was no significant difference in TVFA concentration with respect to UDP levels in the ration.

Forster *et al.* (1983) could not observe any significant change in ruminal $NH_3$–N when cows were fed with 54, 49 or 43 per cent RDP in 14 per cent CP ration. Christensen *et al.* (1993b) reported that both 16.4 and 19.4 CP rations low in RUP (30 per cent) increased the $NH_3$–N concentration compared with same CP rations high in RUP (45 per cent). Zimmerman *et al.* (1992) observed a reduction in rumen ammonia nitrogen level with increased UDP portion in rations with 14.5 and 18.5 per cent CP. Rodriguez *et al.* (1997) observed that rumen ammonia nitrogen was 25 to 45 per cent lower with 41 per cent RUP than that of 29 per cent in 16 per cent CP ration. Kanjanapruthypong *et al.* (2002) also observed a decrease in ruminal $NH_3$–N in response to increase in the content of RUP from formalin treated SBM in the ration. Geerts *et al.* (2004) observed that when daily rumen degraded protein balance increased from 168 to 436 g per day there was a corresponding increase in $NH_3$–N concentration from 10.1 to 12.0 mmol per l.

De Peters and Ferguson (1992) observed that BUN was positively associated with intakes of ruminally degradable and undegradable protein and negatively associated with intakes of energy. Christensen *et al.* (1993a) recorded a reduction in PUN by increasing the RUP from 30 to 45 per cent in both 16.4 and 19.6 per cent CP rations. Rodriguez *et al.* (1997) found that there was no significant difference in the PUN level when UDP of a 16 per cent ration was increased from 29 to 41 per cent. Similar result was reported by Ally (2003) when 17 per cent CP concentrate mixture with 26.8 and 42.9 per cent degradability was fed to cows in early lactation.

# *Materials and Methods*

# 3. MATERIALS AND METHODS

The feeding experiment was conducted in the University Livestock Farm and Fodder Research and Development Scheme (ULF&FRDS), College of Veterinary and Animal Sciences, Mannuthy, using eight early lactating crossbred cows in switch over design with the objective of assessing the effect of urea as a source of rumen degradable protein (RDP) on the milk production as well as on the economics of production.

## 3.1 EXPERIMENTAL ANIMALS

Eight crossbred cows within 20 days of lactation as uniform as possible with regard to their age, parity, weight and milk yield, were selected from ULF& FRDS as the experimental animals. They were allotted to the experimental treatments in a switch over design.

## 3.1 EXPERIMENTAL RATION

The four dietary treatments used in the feeding trial were

T1- Concentrate mixture with 17 per cent crude protein (CP) containing one per cent urea with 25 per cent of CP as UDP

T2- Concentrate mixture with 17 per cent CP containing one per cent urea with 40 per cent of CP as UDP

T3- Concentrate mixture with 20 per cent CP containing one per cent urea with 25 per cent of CP as UDP

T4- Concentrate mixture with 20 percent CP containing one per cent urea with 40 per cent of CP as UDP.

The animals were allotted to the four treatments and all the treatments were isocaloric. The ingredient composition and calculated nutrient content of the four concentrate mixture are represented in Table1 and 2, respectively. Paddy straw formed the sole roughage to the animals.

## 3.3 FEEDING TRIAL

The feeding trial was conducted in a switch over design. Each treatment was given for a period of three weeks and a period of seven days was given in between the treatments to nullify the carry over effects of previous treatment. The total experiment was for 15 weeks.

Initially, the daily dry matter given was fixed at three per cent of body weight, which was revised during each feeding period according to body weight and intake. The experimental animals had free access to clean wholesome drinking water throughout the day. They were fed with the concentrate mixture twice daily, in the morning and in the afternoon before milking. Paddy straw was offered through out the day. The concentrate mixture and paddy straw were fed at the ratio of 70:30 of daily dry matter. Data on the daily DM intake and body weight of animals at the beginning and end of each feeding period were recorded through out the experiment.

## 3.4 MILK SAMPLES

Milk samples were collected at the beginning and end of each feeding period from individual animals and were analysed for total solids, fat (IS: 1224, 1977), protein (AOAC, 1990, N* 6.38), solids not fat (SNF) and milk urea nitrogen (MUN, Bector *et al.*1998). Data on the milk production of individual animal was recorded throughout the experiment.

## 3.5 HAEMATOLOGICAL PARAMETERS

Blood samples from the experimental animals were collected at the beginning and end of each feeding period. These samples were used to determine haemoglobin (cyanmethaemoglobin method), plasma glucose (GOD-PAP method), plasma inorganic phosphorus (phosphomolybdate method), plasma urea nitrogen (modified Berthelot method), plasma creatinine (modified Jaffe's method), plasma total protein (direct Biuret method) and albumin (bromcresol green method) using the kits supplied by Agappe diagnostics, Maharashtra, India. Plasma calcium was estimated by Atomic Absorption Spectrophotometer (Perkin Elmer model – 3110) using hollow calcium cathode tubes.

## 3.6 RUMEN FERMENTATION PARAMETERS

Rumen liquor was collected from all the animals using a stomach tube, at the beginning and end of each feeding period. It was analysed for pH (pH meter, Cyberscan, 2500), total volatile fatty acids (Barnett and Reid, 1957) and rumen ammonia nitrogen (Beecher and Whitten, 1970).

## 3.7 ECONOMICS OF PRODUCTION

Total cost of feed for different dietary treatments was calculated from the cost of ingredients fixed by the Kerala Agricultural University for the year 2004-2005. Cost of feed per kg milk production for the four treatments was calculated from cost of feed, total milk production and quantity of feed consumed by cows in each treatment group.

## 3.8 ANALYSIS OF FEED

Proximate analysis of the four concentrate mixtures and paddy straw was carried out as per standard procedure (AOAC, 1990). The acid detergent fiber (ADF) was estimated by the method suggested by Van Soest (1963) and neutral detergent fiber (NDF) by the method suggested by Van Soest and Whine, (1967). The calcium content in the feed was found out by Atomic Absorption Spectrophotometer using hollow calcium cathode tubes. Phosphorus content in the feed was determined by Vanado-Molybdate method (AOAC, 1990).

## 3.9 STATISTICAL ANALYSIS

The data were analysed by the method of analysis for switch over design (Snedecor and Cochran, 1985).

Table1. Ingredient composition of the four concentrate mixtures given to the experimental animals, kg

| Ingredient, kg | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| Yellow maize | 50.5 | 44.0 | 42.0 | 39.5 |
| Groundnut cake | 10.5 | 4.0 | 19.0 | 11.0 |
| Coconut cake | 0.0 | 29.5 | 0.0 | 36.5 |
| Wheat bran | 35.0 | 18.5 | 35.0 | 9.0 |
| Urea | 1.0 | 1.0 | 1.0 | 1.0 |
| Salt | 1.0 | 1.0 | 1.0 | 1.0 |
| Shell grit | 2.0 | 2.0 | 2.0 | 2.0 |

To every 100 kg of each concentrate mixture, 100 grams of Ultra-TM (Neospark Drugs and Chemicals Pvt Ltd., Hyderabad), 12 grams of Nicomix $AB_2D_3K$ (Nicholas Piramal India Ltd, Mumbai) and 600 grams of sodium bicarbonate were added.

Composition per gram:

Ultra-TM: Manganese-54 mg, Zinc-52 mg, Iron-20 mg, Iodine-2 mg, Copper-2 mg, Cobalt –1mg.

Nicomix $AB_2D_3K$: Vitamin A-82500 I.U, Vitamin $D_3$-12000 I.U, Vitamin $B_2$-50 mg, Vitamin K-10 mg.

Table 2. Calculated nutrient content of the four concentrate mixtures used

| Nutrient | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| CP, per cent | 17.06 | 17.21 | 20.04 | 19.95 |
| RDP, per cent | 12.33 | 10.41 | 14.77 | 11.98 |
| UDP, per cent | 4.73 | 6.80 | 5.27 | 7.97 |
| TDN, per cent | 70.60 | 69.2 4 | 70.26 | 68.98 |
| Calcium, g% | 0.72 | 0.75 | 0.74 | 0.77 |
| Phosphorus, g% | 0.65 | 0.53 | 0.58 | 0.51 |

# *Results*

# 4. RESULTS

The results obtained in the present study are documented under the following headings.

## 4.1 CHEMICAL COMPOSITION

The per cent chemical composition of both the concentrate mixtures and paddy straw along with calcium and phosphorus content are presented in the Table 3. The CP content of the four concentrate mixtures were 16.93 ± 0.08, 17.37 ± 0.09, 19.92 ± 0.14 and 19.92 ± 0.11, while, that of paddy straw used for feeding was 5.20 ± 0.13 on dry matter basis.

## 4.2 BODY WEIGHT

The body weight of experimental animals receiving four dietary treatments, recorded at the end of each feeding period are documented in Table 4 and represented in Fig.1. The initial body weight of the animals in the four groups was 392.5, 369.5, 362.5 and 329 kg, respectively.

## 4.3 DRY MATTER INTAKE (DMI)

Average dry matter intake (kg/day) of the animals was 10.53, 10.54, 10.53 and 10.65, respectively, for four experimental rations, the observation of which is given in Table 5 and the same being represented in Fig.2.

## 4.4 MILK PRODUCTION

The average daily milk yield (Table 6 and Fig. 3) of the animals maintained on four experimental rations were 9.30, 9.68, 8.98 and 9.71 kg, respectively.

## 4.5 MILK COMPOSITION

The average milk fat percentages of the samples collected at the beginning of experiment were 3.5 ± 0.25, 3.6 ± 0.20, 3.65 ± 0.13 and 3.8 ± 0.11 and the mean value of milk protein per cent were 2.64 ± 0.22, 2.67 ± 0.11, 2.72 ± 0.22 and 3.13 ± 0.30, respectively, for animals maintained on the four experimental rations. The initial solids not fat percentages were 9.14 ± 0.47, 8.77 ± 0.48, 8.51 ± 0.92 and 8.81 ± 0.85, total solids percentages were 12.64 ± 0.26, 11.87 ± 0.47, 11.74 ± 0.76 and 11.87 ± 0.55 and the milk urea nitrogen concentrations (mg/100ml) were 44.99 ± 2.22, 37.03 ± 2.08, 41.47 ± 2.32 and 39.25 ± 1.18, respectively, in the four groups.

The same milk parameters estimated from the milk collected from the animals at the end of each feeding period are given in Table 7, 8 and 9. The summarised data on the milk composition is listed in Table10, which is represented in Fig.4 and 5.

## 4.6 RUMEN FERMENTATION PARAMETERS

The data on the rumen fermentation parameters such as pH, ammonia nitrogen and total volatile fatty acids of the rumen liquor from the animals collected at the end of each feeding period are given in Table11. The summarised data of the same are given in Table12 and are represented in Fig. 6. The initial rumen pH of animals in the four groups were 7.12 ± 0.22, 7.23 ± 0.16, 6.45 ± 0.11 and 7.4 ± 0.14, total volatile fatty acid concentrations (meq/l) were 70.5 ± 13.5, 72 ± 2.0, 76.5 ± 6.5 and 111 ± 3.0 and rumen $NH_3$ levels (mg/100ml) were 14.33 ± 2.72, 21.57 ± 2.20, 19.73 ± 0.27 and 31.30 ± 1.21, respectively in the four groups.

## 4.7 HAEMATOLOGICAL AND BIOCHEMICAL PARAMETERS

The blood was collected at the beginning and end of each feeding period. The haemoglobin concentration (g/100ml) at the beginning of feeding period was

9.83 ± 0.70, 9.18 ± 2.05, 7.89 ± 0.74 and 8.61 ± 0.82, plasma glucose level (mg/100ml) was 44.23 ± 1.31, 49.34 ± 3.81, 43.59 ± 1.41and 45.41 ± 1.27, plasma urea nitrogen (mg/100ml) was 10.16 ± 2.26, 16.16 ± 1.77, 15.59 ± 2.94 and 16.05 ± 1.61and plasma creatinine (mg/100ml) was 1.08 ± 0.08, 1.01 ± 0.12, 1.13 ± 0.14 and 1.12 ± 0.078, respectively, for the animals maintained on the four experimental rations. The initial plasma calcium (mg/100ml) of animals fed four rations was 9.14 ± 0.37, 8.85 ± 0.05, 9.13 ± 0.13 and 10.58 ± 0.40 and plasma phosphorus (mg/100ml) was 5.67 ± 0.72, 3.6 ± 0.45, 4.74 ± 0.37 and 4.94 ± 0.42, respectively. The plasma total protein (g/100ml) was 5.95 ± 0.46, 6.30 ± 0.13, 6.78 ± 0.59 and 6.70 ± 0.45 and albumin (g/100ml) was 2.47 ± 0.18, 2.50 ± 0.25, 2.98 ± 0.09 and 2.89 ± 0.01, respectively, for the animals maintained on the four experimental rations.

The data on the same haematological and biochemical parameters in the blood samples collected at the end of each feeding period are given in Table 13, 14, 15 and 16. The average values of the same are presented in Table17 and Fig. 7, 8, 9 and 10.

## 4.8 ECONOMICS OF PRODUCTION

The total dry matter intake, DMI per 100 kg body weight, DMI per kg metabolic live weight and cost of feed per kg milk production are depicted in Table 18 and the same data are given in Fig.11.

Table 3. Chemical composition of the four concentrate mixtures and paddy straw fed to experimental animals*, %

| Parameter | Concentrate mixtures | | | | Paddy straw |
|---|---|---|---|---|---|
| | I | II | III | IV | |
| Dry matter | 88.82 ± 0.30 | 89.38 ± 0.41 | 89.03 ± 0.27 | 89.60 ± 0.57 | 90.41 ± 0.64 |
| Crude protein | 16.93 ± 0.08 | 17.37 ± 0.09 | 19.92 ± 0.14 | 19.92 ± 0.11 | 5.20 ± 0.13 |
| Ether extract | 5.52 ± 0.45 | 6.32 ± 0.28 | 4.31 ± 0.39 | 6.08 ± 0.57 | 1.77 ± 0.32 |
| Crude fibre | 8.78 ± 0.55 | 9.07 ± 0.72 | 10.84 ± 0.72 | 8.27 ± 0.56 | 31.88 ± 0.78 |
| Total ash | 10.11 ± 0.74 | 7.78 ± 0.34 | 10.21 ± 0.07 | 8.38 ± 0.55 | 17.02 ± 0.48 |
| Nitrogen free extract | 58.66 ± 1.05 | 59.46 ± 0.36 | 54.72 ± 1.03 | 57.35 ± 1.45 | 44.13 ± 0.58 |
| Acid insoluble ash | 3.24 ± 0.17 | 2.11 ± 0.16 | 3.34 ± 0.26 | 1.85 ± 0.35 | 12.99 ± 0.33 |
| Neutral detergent fibre | 28.63 ± 0.84 | 30.24 ± 0.75 | 28.06 ± 0.46 | 30.67 ± 0.84 | 71.48 ± 0.66 |
| Acid detergent fibre | 13.29 ± 1.18 | 14.68 ± 1.4 | 16.89 ± 1.42 | 16.23 ± 0.77 | 48.58 ± 1.06 |
| Acid detergent lignin | 6.03 ± 0.59 | 6.62± 0.82 | 5.34 ± 0.94 | 5.78 ± 0.94 | 4.49 ± 0.99 |
| Calcium | 0.98 ± .096 | 1.08 ± 0.12 | 1.08 ± 0.115 | 1.02 ± 0.04 | 0.23 ± 0.04 |
| Phosphorus | 0.43 ± 0.02 | 0.47 ± 0.018 | 0.48 ± 0.02 | 0.47 ± 0.02 | 0.26 ± 0.14 |

* Average of six values on DM basis

Table 4. Average body weight of animals maintained on the four experimental rations, kg

| Period | Body weight, * kg | | | | P value |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | |
| 1 | 372 | 338 | 346 | 303 | |
| 2 | 303 | 386 | 352 | 353 | |
| 3 | 353 | 316 | 390 | 358 | |
| 4 | 360 | 359 | 317 | 396 | |
| Mean ± SE | 347 ±10.20 | 350 ±12.76 | 351 ±12.81 | 352 ±15.77 | 0.65 |

* Mean of two values

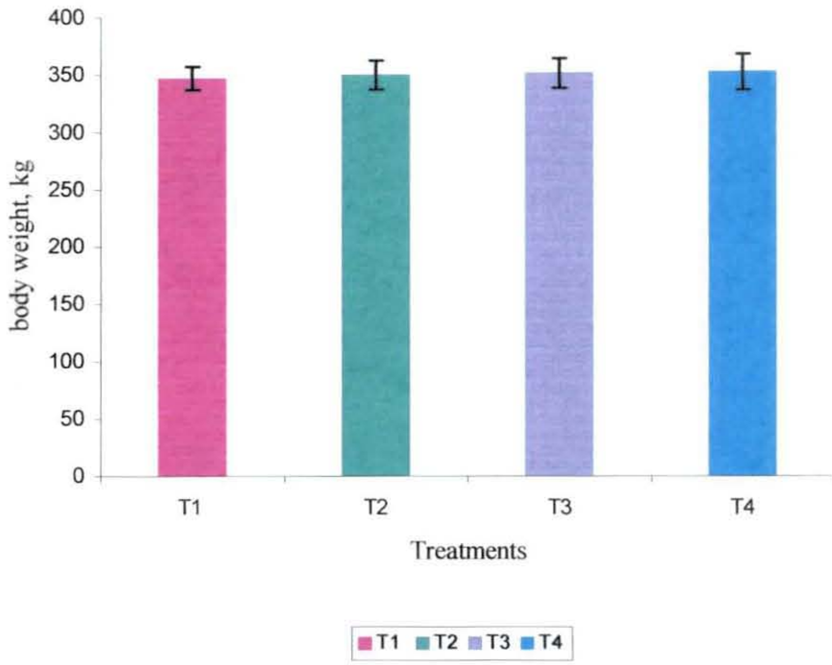


Fig. 1. Average body weight of animals maintained on the four experimental rations

Table 5. Average daily dry matter intake of animals maintained on the four experimental rations, kg

| Period | Dry matter intake*, kg | | | | P value |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | |
| 1 | 11.61 | 11.00 | 10.73 | 9.66 | |
| 2 | 9.37 | 11.53 | 10.94 | 10.77 | |
| 3 | 10.62 | 9.05 | 10.89 | 10.53 | |
| 4 | 10.52 | 10.59 | 9.56 | 11.66 | |
| Mean ± SE | 10.53 ± 0.40 | 10.54 ± 0.44 | 10.53 ± 0.35 | 10.65 ± 0.39 | 0.37 |

* Mean of two values

Table 6. Average daily milk yield of animals maintained on the four experimental rations, kg

| Period | Milk yield, * kg | | | | P value |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | |
| 1 | 11.05 | 10.47 | 9.73 | 13.20 | |
| 2 | 10.24 | 9.61 | 8.40 | 10.12 | |
| 3 | 9.46 | 9.98 | 8.79 | 7.71 | |
| 4 | 6.50 | 8.71 | 9.00 | 7.83 | |
| Mean ±SE | 9.30 ± 0.80 | 9.68 ± 0.45 | 8.98 ± 0.43 | 9.71 ± 0.96 | 0.31 |

* Average of two values

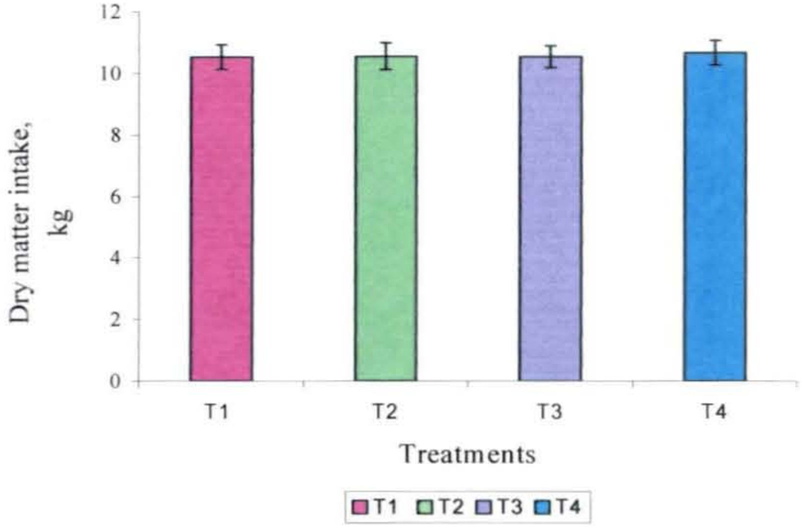


Fig. 2. Average daily dry matter intake of animals maintained on the four experimental rations

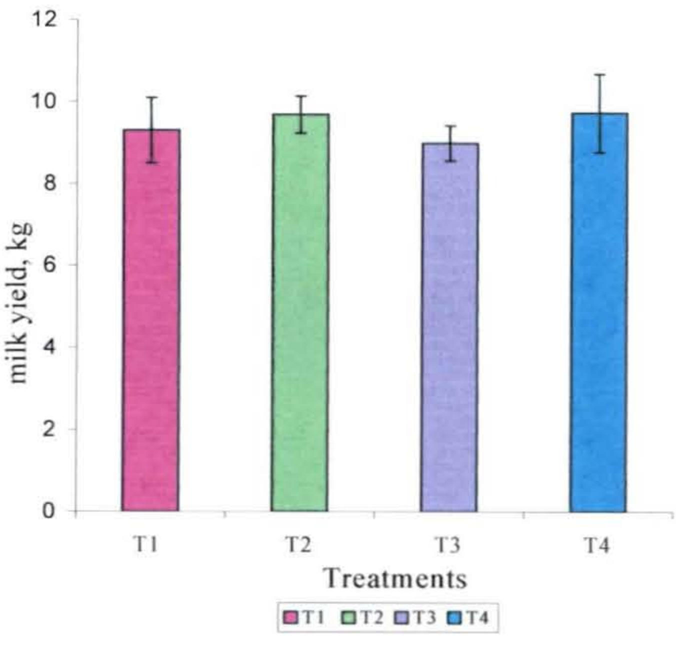


Fig. 3. Average daily milk production of animals maintained on the four experimental rations

Table 7. Milk fat and solids not fat percentages of animals maintained on the four experimental rations.

| Parameter | Treatments* | Period | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | Mean ± SE |
| Milk fat, % | T1 | 3.60 | 4.05 | 4.05 | 4. 55 | 4.06 ± 0.33 |
| | T2 | 3.10 | 3.65 | 4.30 | 4.75 | 3.95 ± 0.29 |
| | T3 | 3.40 | 4.15 | 4.20 | 4.25 | 4.0 ± 1.80 |
| | T4 | 3.50 | 3.80 | 4.60 | 4.40 | 4.08 ± 0.24 |
| Solids not fat, % | T1 | 8.20 | 8.26 | 9.40 | 9.65 | 8.88 ± 0.30 |
| | T2 | 8.07 | 9.01 | 7.90 | 8.23 | 8.30 ± 0.35 |
| | T3 | 7.95 | 8.69 | 9.41 | 8.34 | 8.60 ± 0.21 |
| | T4 | 8.36 | 8.90 | 8.97 | 8.80 | 8.76 ± 0.34 |

* Mean of two values

Table 8. Milk protein and total solids percentages of animals maintained on the four experimental rations.

| Parameter | Treat* ments | Period | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | Mean ± SE |
| Milk protein, % | T1 | 2.35 | 2.68 | 3.23 | 2.71 | 2.86 ± 0.17 |
| | T2 | 2.54 | 2.38 | 2.47 | 2.84 | 2.55 ± 0.14 |
| | T3 | 3.02 | 2.99 | 2.68 | 2.31 | 2.76 ± 0.12 |
| | T4 | 2.71 | 3.18 | 2.63 | 2.30 | 2.64 ± 0.15 |
| Total solids, % | T1 | 11.45 | 12.81 | 13.41 | 13.45 | 12.85 ± 0.37 |
| | T2 | 12.11 | 11.37 | 12.53 | 12.53 | 12.16 ± 0.51 |
| | T3 | 12.81 | 12.84 | 12.15 | 12.15 | 12.60 ± 0.14 |
| | T4 | 12.30 | 12.77 | 12.95 | 12.95 | 12.83 ± 0.27 |

* Mean of two values

Table 9. Milk urea nitrogen concentration (MUN) of animals maintained on the four experimental rations, mg/100ml

| Period | MUN, mg/100ml* | | | |
|---|---|---|---|---|
| | T1 | T2 | T3 | T4 |
| 1 | 41.59 | 39.83 | 41.29 | 34.62 |
| 2 | 35.78 | 37.75 | 44.04 | 40.79 |
| 3 | 43.25 | 37.47 | 50.20 | 52.98 |
| 4 | 42.08 | 36.09 | 41.10 | 39.29 |
| Mean ± SE | $40.67^{a}\pm1.61$ | $37.77^{a}\pm1.01$ | $44.15^{b}\pm2.51$ | $41.92^{b}\pm2.69$ |

*Mean of two values

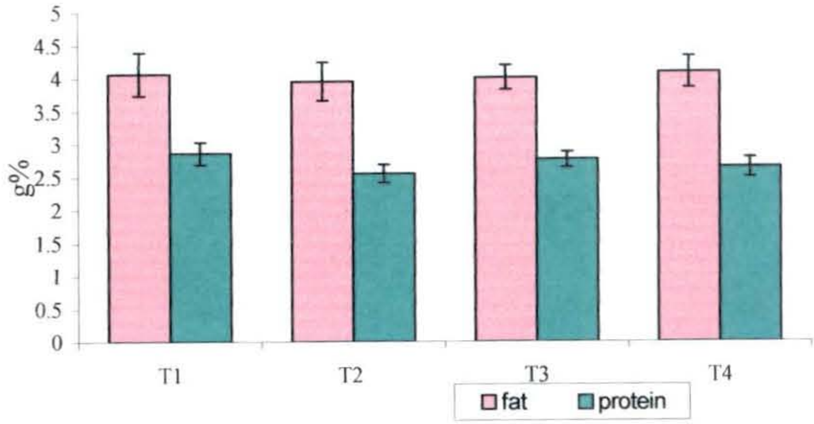


Fig. 4 . Milk fat and protein percentages of animals maintained on the four experimental rations

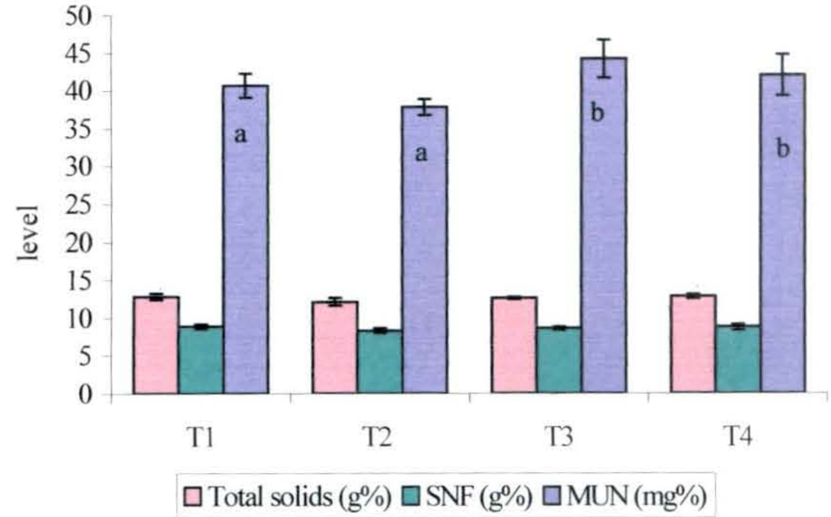


Fig. 5 . Total solids, solids not fat percentages and milk urea nitrogen concentrations of the animals maintained on the four experimental rations

Table 10. Summarised data on average milk composition parameters in animals maintained on the four experimental rations*

| Parameter | T1 | T2 | T3 | T4 | P value |
|---|---|---|---|---|---|
| Fat, g% | 4.06 ± 0.33 | 3.95 ± 0.29 | 4.0 ± 1.80 | 4.08 ± 0.24 | 0.89 |
| SNF, g% | 8.88 ± 0.30 | 8.30 ± 0.35 | 8.60 ± 0.21 | 8.76 ± 0.34 | 0.11 |
| Protein, g% | 2.86 ± 0.17 | 2.55 ± 0.14 | 2.76 ± 0.12 | 2.64 ± 0.15 | 0.14 |
| Total solids, g% | 12.8 ± 0.37 | 12.1 ± 0 .51 | 12.6 ± 0.14 | 12.8 ± 0.27 | 0.39 |
| MUN, mg% | $40.67^{a}$ ±1.61 | $37.77^{a}$ ±1.01 | $44.15^{b}$ ±2.51 | $41.92^{b}$ ±2.69 | 0.03 |

* Mean of eight values

a, b – Means with different superscripts in the same row differ significantly (P<0.05).

Table 11. Rumen fermentation parameters of animals maintained on the four experimental rations

| Parameter | Treatments* | Period | | | | Mean ± SE |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| Rumen pH | T1 | 7.38 | 7.50 | 7.29 | 6.93 | 7.28 ± 0.24 |
| | T2 | 7.37 | 7.48 | 7.73 | 7.08 | 7.44 ± 0.15 |
| | T3 | 7.30 | 7.72 | 7.71 | 7.21 | 7.49 ± 0.19 |
| | T4 | 7.35 | 6.92 | 7.79 | 7.29 | 7.34 ± 0.15 |
| TVFA (meq/l) | T1 | 72.00 | 110.00 | 123.00 | 136.00 | 110 ± 10.2 |
| | T2 | 76.50 | 103.00 | 98.50 | 99.50 | 94.38 ± 4.26 |
| | T | 111.50 | 98.50 | 110.00 | 109.50 | 107.38 ± 13.01 |
| | T4 | 70.50 | 94.25 | 127.50 | 93.50 | 96.44 ± 12.30 |
| $NH_3$-N (mg/100ml) | T1 | 21.42 | 16.23 | 28.97 | 27.22 | 23.46 ± 3.32 |
| | T2 | 19.73 | 13.79 | 10.36 | 25.72 | 17.40 ± 2.45 |
| | T3 | 31.31 | 18.82 | 25.63 | 35.64 | 27.85 ± 2.95 |
| | T4 | 14.33 | 11.21 | 24.32 | 42.98 | 23.21 ± 5.18 |

*Average of two values

Table 12. Summarised data on average rumen fermentation parameters in animals maintained on the four experimental rations*

| Parameter | T1 | T2 | T3 | T4 | P value |
|---|---|---|---|---|---|
| Rumen $P^H$ | 7.28 ± 0.24 | 7.44 ± 0.15 | 7.49 ± 0.19 | 7.34 ± 0.15 | 0.13 |
| $NH_3$-N, mg/100ml | 23.46 ± 3.32 | 17.40 ± 2.45 | 27.85 ± 2.95 | 23.21 ± 5.18 | 0.08 |
| TVFA, meq/l | 110 ±10.20 | 94.38 ± 4.26 | 107.38 ±13.0 | 96.44 ± 2.30 | 0.60 |

* Mean of eight values

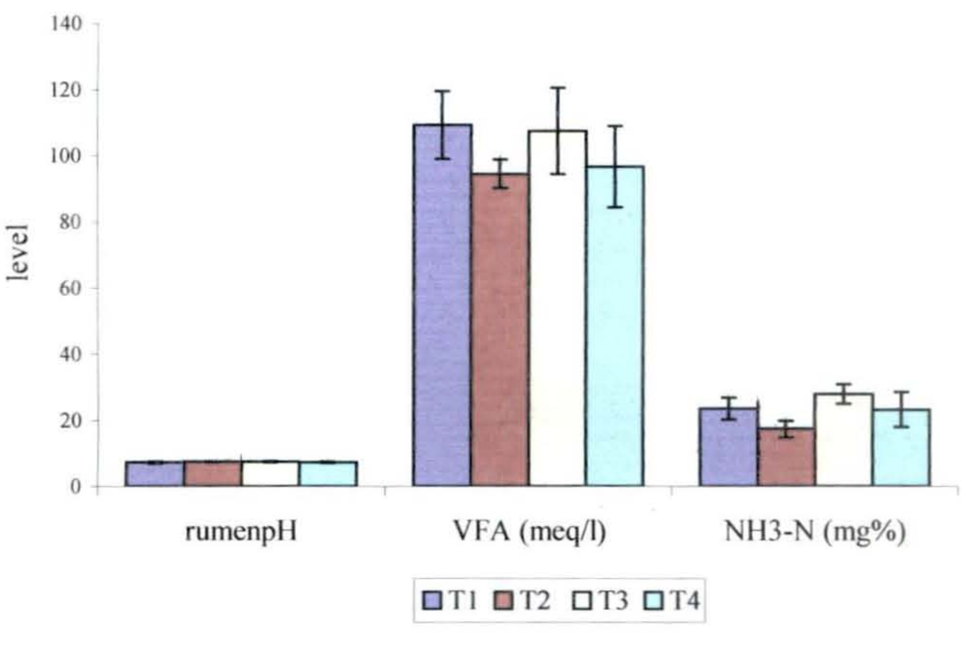


Fig. 7. Rumen fermentation parameters of animals maintained on the four experimental rations.

Table 13. Plasma glucose levels (PGL) and haemoglobin (Hb) of animals maintained on four experimental rations

| Parameter | Treatments* | Period | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| PGL, mg/100ml | T1 | 51.06 | 46.79 | 43.84 | 43 | 46.17 ± 1.67 |
| | T2 | 52.96 | 47.40 | 41.36 | 43.5 | 46.32 ± 1.88 |
| | T3 | 49.99 | 50.86 | 50.17 | 48.18 | 49.80 ± 2.35 |
| | T4 | 57.13 | 54.00 | 43.98 | 43.00 | 49.53 ± 2.39 |
| Hb, g/100ml | T1 | 9.23 | 8.12 | 9.09 | 9.31 | 8.93 ± 0.35 |
| | T2 | 7.00 | 10.32 | 7.43 | 11.02 | 8.95 ± 0.69 |
| | T3 | 7.16 | 8.20 | 9.56 | 7.56 | 8.13 ± 0.43 |
| | T4 | 8.10 | 8.30 | 8.66 | 9.78 | 8.71 ± 0.41 |

* Mean of two values

Table 14. Plasma urea nitrogen (PUN) and creatinine of animals maintained on four experimental rations, mg/100ml

| Parameter | Treatments* | Period | | | | Mean ± SE |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| PUN | T1 | 8.59 | 9.90 | 19.53 | 13.19 | 12.81 ± 1.66 |
| | T2 | 19.03 | 15.69 | 18.45 | 10.41 | 15.90 ± 1.48 |
| | T3 | 25.02 | 15.54 | 14.66 | 14.61 | 17.46 ± 1.82 |
| | T4 | 13.07 | 10.20 | 15.28 | 16.70 | 13.82 ± 1.03 |
| Creatinine | T1 | 1.25 | 0.92 | 1.67 | 1.31 | 1.29 ± 0.22 |
| | T2 | 1.19 | 1.11 | 1.48 | 1.71 | 1.37 ± 0.13 |
| | T3 | 1.21 | 1.00 | 1.68 | 1.02 | 1.23 ± 0.14 |
| | T4 | 1.50 | 1.21 | 2.09 | 1.48 | 1.57 ± 0.18 |

* Mean of two values

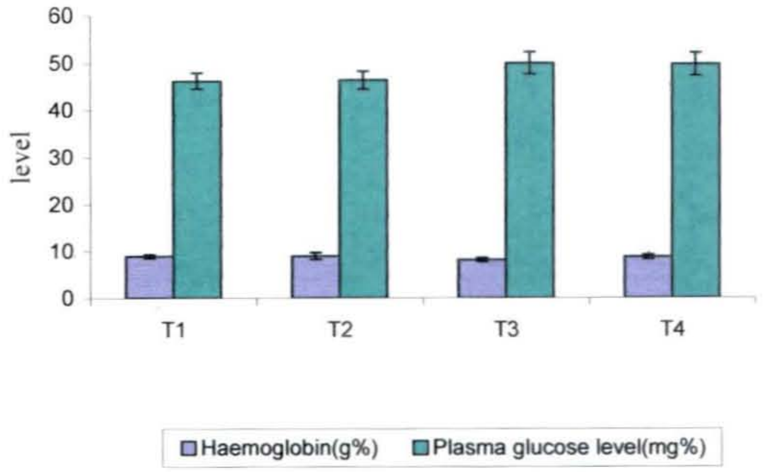


Fig.7. Plasma glucose levels and haemoglobin of animals maintained on the four experimental rations

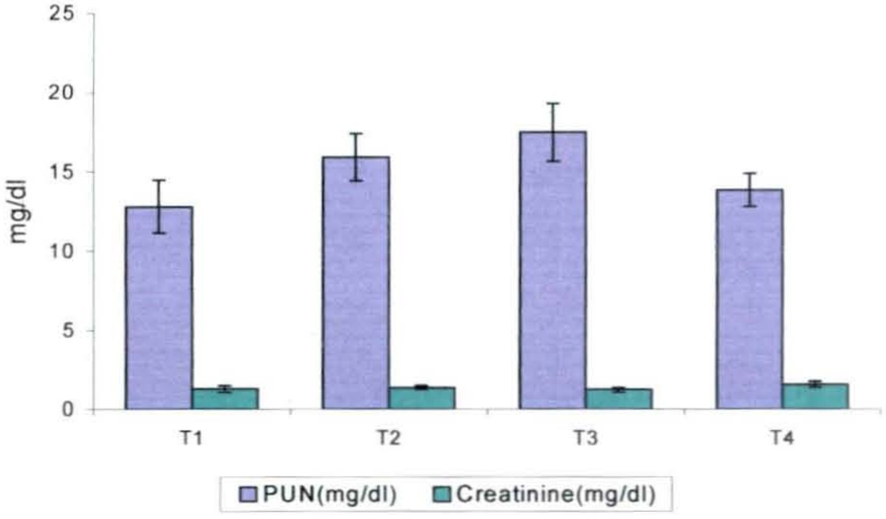


Fig. 8. Plasma urea nitrogen (PUN) and creatinine of animals maintained on the four experimental rations

Table 15. Plasma calcium and phosphorus of animals maintained on four experimental rations, mg/100ml

| Parameter | Period | | | | | |
|---|---|---|---|---|---|---|
| | Treatments* | 1 | 2 | 3 | 4 | Mean ± SE |
| Calcium | T1 | 9.80 | 9.22 | 8.17 | 8.17 | 8.84 ± 0.43 |
| | T2 | 8.52 | 8.5 | 10.82 | 8.75 | 9.15 ± 0.40 |
| | T3 | 9.22 | 8.25 | 9.20 | 10.10 | 9.19 ± 0.59 |
| | T4 | 10.07 | 9.00 | 10.45 | 9.00 | 9.64 ± 0.35 |
| Phosphorus | T1 | 3.90 | 4.93 | 6.53 | 4.67 | 5.0 ± 0.46 |
| | T2 | 3.78 | 5.38 | 5.55 | 5.23 | 4.99 ± 0.41 |
| | T3 | 4.91 | 4.90 | 6.07 | 3.28 | 4.79 ± 0.44 |
| | T4 | 4.09 | 5.91 | 6.09 | 4.94 | 5.26 ± 0.33 |

* Mean of two values

Table 16. Plasma total protein and albumin of animals maintained on the four experimental rations, g/100 ml

| Parameter | Period | | | | | |
|---|---|---|---|---|---|---|
| | Treatments* | 1 | 2 | 3 | 4 | Mean ± SE |
| Total protein | T1 | 6.48 | 7.93 | 7.63 | 6.38 | 7.11 ± 0.33 |
| | T2 | 7.27 | 7.74 | 5.85 | 5.57 | 6.61 ± 0.41 |
| | T3 | 7.36 | 6.53 | 6.21 | 6.52 | 6.65 ± 0.33 |
| | T4 | 7.25 | 7.35 | 6.20 | 6.61 | 6.85 ± 0.27 |
| Albumin | T1 | 3.75 | 2.80 | 3.29 | 3.12 | 3.24 ± 0.15 |
| | T2 | 4.09 | 3.30 | 2.94 | 3.85 | 3.55 ± 0.18 |
| | T3 | 4.30 | 3.32 | 2.90 | 3.32 | 3.46 ± 0.21 |
| | T4 | 4.30 | 2.81 | 3.05 | 3.31 | 3.37 ± 0.23 |

* Mean of two values

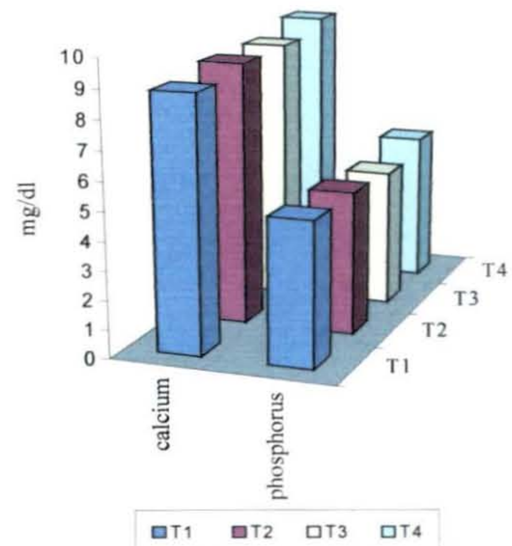


Fig. 9. Plasma calcium and phosphorus of animals maintained on the four experimental rations

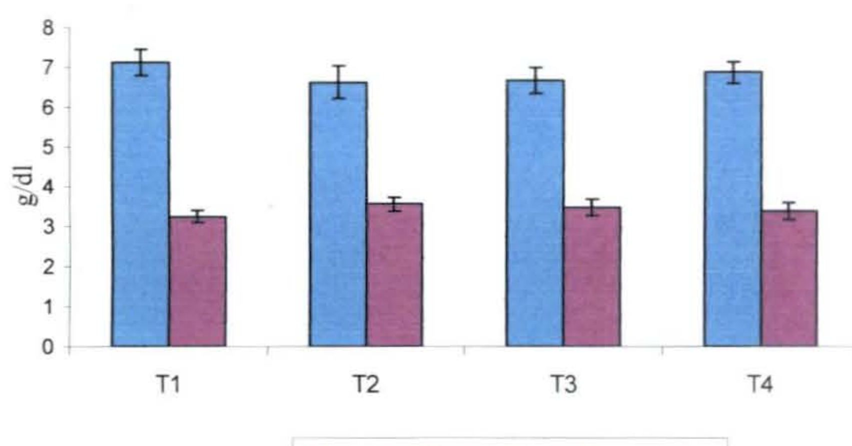


Fig. 10. Plasma total protein and albumin of animals maintained on the four experimental rations

Table 17. Summarised data on average haematological and biochemical parameters of the animals maintained on the four experimental rations*

| Parameter | T1 | T2 | T3 | T4 | P value |
|---|---|---|---|---|---|
| PGL,mg% | 46.17 ± 1.67 | 46.32 ± 1.88 | 49.80 ± 2.35 | 49.53 ± 2.39 | 0.40 |
| Hb, g% | 8.93 ± 0.35 | 8.95 ± 0.69 | 8.13 ± 0.43 | 8.71 ± 0.41 | 0.51 |
| PUN, mg% | 12.81 ± 1.66 | 15.90 ± 1.48 | 17.46 ± 1.82 | 13.82 ± 1.03 | 0.19 |
| Creatinine, mg% | 1.29 ± 0.22 | 1.37 ± 0.13 | 1.23 ± 0.14 | 1.57 ± 0.18 | 0.31 |
| Calcium, mg% | 8.84 ± 0.43 | 9.15 ± 0.40 | 9.19 ± 0.59 | 9.64 ± 0.35 | 0.67 |
| Phosphorus, mg% | 5.00 ± 0.46 | 4.99 ± 0.41 | 4.79 ± 0.44 | 5.26 ± 0.33 | 0.79 |
| Total protein, g% | 7.11 ± 0.33 | 6.61 ± 0.41 | 6.65 ± 0.33 | 6.85 ± 0.27 | 0.69 |
| Albumin, g% | 3.24 ± 0.15 | 3.55 ± 0.18 | 3.46 ± 0.21 | 3.37 ± 0.23 | 0.56 |

* Mean of eight values

Table 18. Economics of milk production of animals maintained on the four experimental rations

| Parameter | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| Total concentrate mixture consumed, kg | 1380.80 | 1353.40 | 1374.00 | 1382.80 |
| Total straw consumed, kg | 597.50 | 603.75 | 608.75 | 610.25 |
| Total feed consumed, kg | 1978.30 | 1957.15 | 1982.75 | 1993.05 |
| Dry matter intake (DMI) per 100 kg body weight | 3.03 | 3.01 | 3.00 | 3.03 |
| DMI per kg metabolic body weight (W kg $^{0.75}$) | 13.10 | 13.09 | 12.99 | 13.10 |
| Total milk produced in 84 days, kg | 1562.40 | 1627.90 | 1508.64 | 1631.24 |
| Feed intake per kg milk produced, kg | 1.27 | 1.20 | 1.314 | 1.22 |
| Cost of one kg concentrate mixture, Rs* | 7.01 | 8.51 | 7.61 | 9.50 |
| Cost of one kg paddy straw used, Rs | 2.77 | 2.77 | 2.77 | 2.77 |
| Total cost of feed, Rs | 11334.00 | 13190.00 | 12142.00 | 14827.00 |
| Cost of feed per kg milk produced, Rs | 7.25 | 8.10 | 8.05 | 9.09 |

* Calculated using the rate contract values fixed for feed ingredients by College of Veterinary and Animal Sciences, Mannuthy, for 2004-2005

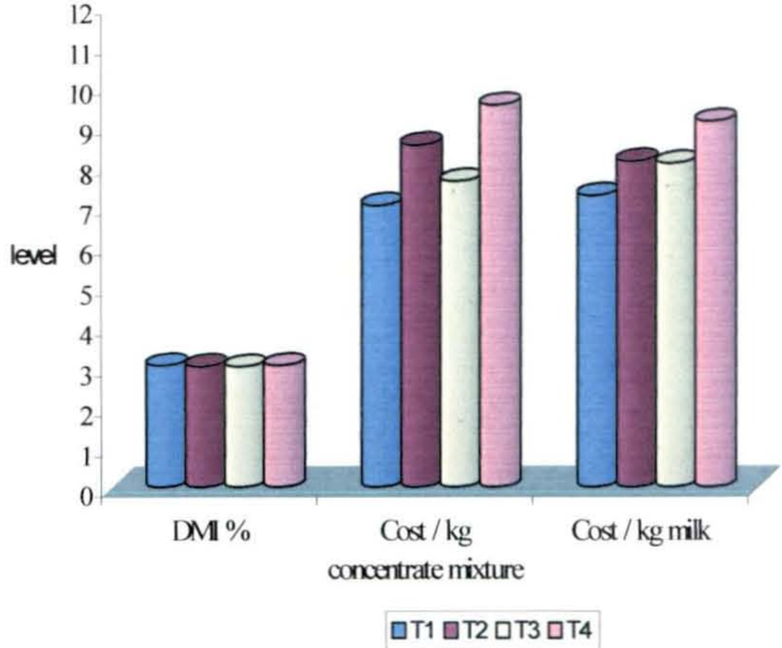


Fig. 11. Economics of milk production of animals maintained on the four experimental rations

# *Discussion*

# 5. DISCUSSION

The results obtained in the present study are discussed under the following headings.

## 5.1 CHEMICAL COMPOSITION

The crude protein (CP) level in the four concentrate mixtures were16.93, 17.37, 19.92 and 19.92 per cent, respectively and that of paddy straw was 5.20 per cent (Table 3). The CP content of the four rations formulated with concentrate and roughage in the ratio of 70: 30 of the total dry matter intake was 13.41, 13.71, 15.50 and 15.50 per cent, respectively. As per National Research Council (NRC, 1971) a CP level of 13 to 14 per cent of dry matter of a complete ration is sufficient to meet the requirement of lactating cows unless the production is too high where as Bureau of Indian Standards (BIS, 1992) has specified a CP level of 22 and 20 for grade 1 and II compounded feed for dairy cattle. For dairy cows producing around 30 kg milk, a ration CP of 15 per cent was recommended by Edwards *et al.* (1980) and Ha and Kennely (1984) while a higher level of 19 to 20 per cent was suggested by Blauwiekel and Kincaid (1986) and Howard *et al.* (1987). Clark and Davis (1980) suggested that a CP level of 13 to14 per cent in the ration was sufficient to meet the protein requirement of dairy cows producing 20 kg milk per day. Ally (2003) reported that a CP level of 13.2 per cent in the ration was sufficient to meet the protein requirement of early lactating crossbred cows producing about 10 kg milk per day.

The calculated TDN content of the four concentrate mixtures were 70.60, 69.24, 70.26 and 68.98 per cent respectively. The acid detergent fibre (ADF) content of four rations constituted by the concentrate mixture and paddy straw in the ratio of 70: 30 were 23.87, 24.84, 26.39 and 25.93 per cent respectively. An ADF level of 17 to 18 per cent was followed by Barney *et al.* (1981) and Annexstad *et al.* (1987) and 19 per cent by Rodriguez *et al.* (1997) in dairy rations. However, rations with ADF level of above 25 per cent was recommended by Roffler and Thacker (1983) and Macleod *et al.* (1984) for cows in early lactation. Ensminger *et al.* (1990) suggested a minimum of 17 per cent ADF during early lactation and Cunningham *et al.* (1996) formulated rations with ADF levels ranging from 17.1 to 26.5 per cent for cows in early lactation.

The neutral detergent fibre (NDF) content of the four rations constituted by the concentrate mixture and paddy straw in the ratio of 70: 30 was 41.48, 42.60, 41.08 and 42.90 per cent respectively. A minimum of 28 per cent NDF during early lactation was recommended by Ensminger *et al.* (1990). NDF level of 21 per cent was followed by Rodriguez *et al.* (1997) and Greenfield *et al.* (2000) and NDF level of 30 and 40 per cent was used by Kauffman and St-Pierre (2001) in 13 and 17 CP rations. Broderick (2003) formulated rations with 36, 32 and 28 per cent NDF in 15, 16.7 and 18.4 per cent CP rations.

The four concentrate mixtures (16.93, 17.37, 19.92 and 19.92 per cent CP) used in this feeding trial contained calculated undegradable protein (UDP) levels as 28, 39.15, 26.46 and 40 per cent of CP and rumen degradable protein (RDP) levels as 72, 61.85, 73.54 and 60 per cent of CP, respectively, on DM basis. The UDP and RDP content of the four concentrate mixtures was calculated using the published UDP content of the ingredients (Ensminger *et al.*, 1990). Coconut cake was added as UDP supplement to the second and fourth dietary treatments to increase the UDP level from 25 to 40 per cent of CP. NRC (1989) recommended 36.6 to 43.3 per cent UDP and 49.8 to 74 per cent RDP of ration CP for 400 kg cows producing 7 to 13 kg milk per day. In the present feeding trial, all the diets appeared to provide sufficient RDP from urea and ground nut cake to meet the needs of ruminal microorganisms for amino acids, ammonia nitrogen and peptides for protein synthesis.

All the four dietary treatments contained one per cent urea as source of RDP. Urea is the most commonly used non protein nitrogen (NPN) source because of its low cost and availability. Rumen microbes utilize the ammonia released in the rumen from the hydrolysis of urea, for the microbial protein synthesis. Garg (1998) suggested that diets with high amount of rumen undegradable protein (RUP), RDP should be included to maintain a source of ruminally available nitrogen. Sannes *et al.* (2002) reported that urea added as source of RDP in 18.5 CP ration was effective in maintaining the milk production, dry matter intake and microbial protein synthesis in early lactation.

5.2 BODY WEIGHT

The average body weight of the animals at the beginning of the feeding trial were 393, 370, 363 and 329, respectively, in the four dietary groups. At the end of the first period (three weeks), the corresponding weight were 372, 338, 346 and 303 kg, respectively, indicating a loss of 21 kg in the first, 32 kg in the second and 17 kg in the third and 26 kg in the fourth group, the loss in weight being highest in the animals fed 17 per cent CP concentrate mixture with 39.15 per cent of protein as UDP (Table 4). Earlier research workers have also reported that dairy cows lose body weight in early lactation, as they will be in negative energy balance (Clark and Davis, 1980; Roffler and Thacker, 1983; Blauwiekel and Kancaid, 1986; Howard *et al.*, 1987)

During the second period there was no change in the body weight of animals given 17 per cent CP with 28 per cent UDP concentrate mixture, while, an increase of 14 kg in 17 per cent CP with 39.15 per cent UDP, 16 kg in 20 per cent CP with 26.46 per cent UDP and 8 kg in 20 per cent CP with 40 per cent UDP groups were recorded.

The animals given 17 per cent CP concentrate mixture with 28 per cent UDP continued to maintain their body weight during the third and fourth period also. The animals fed with same CP ration with 39.15 per cent UDP, the body weight increased during the third (14 kg) and fourth period (6 kg), respectively.

In the case of 20 per cent CP concentrate mixture with 26.46 per cent of CP as UDP fed group, the body weight increased by 4 kg in the third period and one kg in the fourth period, while, with 40 per cent of CP as UDP fed group the increase in body weight was uniform (6 kg) both during the third and fourth period.

The body weights of the experimental animals receiving the four dietary treatments, recorded at the end of each feeding period are documented in Table 4. The average body weight of animals in the four groups at the end of feeding trial was 347, 350, 351 and 352 kg, respectively and there was no significant difference (P>0.05) between the body weights of animals of the different dietary groups.

A lack of influence of dietary CP levels on body weight of early lactating cows was also reported by Edwards *et al.* (1980) with 13, 15 and 17 per cent CP, Baxter *et al.* (1983) with 12.8, 15 and 17 per cent, Leonard and Block *et al.* (1988) with 15.4 and 20.7 per cent, Cunningham *et al.* (1996) with 14.5, 16.5 and 18.5 per cent, Ally (2003) with 13.2 and 20 per cent and Noftsger and St- Pierre (2003) with 17 and 18.3 per cent CP rations. In contrary to this, Ha and Kennely (1984) observed that cows fed 13.5 per cent CP ration lost 0.43 kg per day where as those at 15, 17 and 19 gained 0.59, 0.38 and 0.59 kg per day in early lactation. Ally (2003) observed an increase in body weight of animals fed 15.4 per cent CP ration compared to 13.2 and 20 per cent CP ration.

The level of undegradable protein (UDP) also did not affect the body weight of animals in the present study. Zimmerman *et al.* (1991) reported that UDP levels had no significant effect of on body weights when cows fed 14, 18 and 22 per cent CP rations with different levels of UDP varying from 36.8 to 44.8 per cent. Similar lack of influence of dietary UDP levels on body weight were also observed by Triplett *et al.* (1995) using rations with 37, 51 and 76 per cent UDP, Ally (2003) with 26.8 and 42.9 per cent UDP and Davidson *et al.* (2003) with UDP levels ranging from 36 to 46 per cent in the ration. But Crish *et al.* (1986) observed that the animals fed 15 per cent CP ration with 43 per cent UDP lost more weight compared to 67 per cent UDP ration.

## 5.3 DRY MATTER INTAKE (DMI)

The average daily dry matter intake (DMI) of animals in the four groups is documented in Table 5. There was no significant difference (P>0.05) between the DMI of animals (10.53, 10.54, 10.53, and 10.65 kg, respectively) given the four dietary treatments. All the diets were consumed readily and feed refusal was almost nil. No disruption in the DMI was observed during the switch over from adaptation period to the next feeding period. The DMI per 100 kg body weight of the animals in the four groups were also similar (3.03, 3.01, 3.0 and 3.03 per cent, respectively, Table19). The observation made in the present study is in agreement with the reports of Cressman *et al.* (1980) in which different levels of dietary CP (12, 15 and 18 per cent) did not affect the total DMI. Henderson *et al.* (1985) and Khorasani *et al.* (1994) also observed that DMI was not affected by dietary CP levels or source of protein added in the ration. Ally (2003) reported that there was no significant difference in DMI when crossbred cows in early lactation were fed rations with 13.2 and 15.4 per cent CP. In contrast, Barney *et al.* (1981) with 13 and 17 per cent CP, Macleod *et al.* (1984) with 12, 15 and 18 per cent CP and Broderick (2003) with 15.1, 16.7 and 18.4 per cent CP rations reported an increase in DMI in response to an increase in dietary CP levels.

Erdman and Vandersall (1983) reported a lack of significant effect of level of UDP on DMI when cows fed 14 per cent CP ration at two levels of UDP (24 and 47 per cent). Similarly, McGuffey *et al.* (1990) did not observe any change in the DMI with 14 and 17 per cent CP rations having UDP of 33 and 40 per cent. Similar observation of uniform feed consumption irrespective of a change in UDP levels in the ration has been reported by many workers (Hoffman *et al.*, 1991; Nianogo *et al.*, 1991; Aharoni *et al.*, 1993; Davidson *et al.*, 2003). In contrast, Kalbande and Thomas (1999) reported that increasing the level of undegradable protein (UDP) of concentrate mixture from 30 to 63 per cent increased DMI in crossbred cows maintained on low quality roughage and producing around 10 kg milk per day.

## 5.4 MILK PRODUCTION

The average daily milk production of the animals maintained on the experimental rations is given in Table 6 and the same were 9.30, 9.68, 8.98 and 9.71 kg, respectively, for the four dietary treatments. It was observed that milk yield was not affected (P>0.05) by the levels of CP or degradability in the ration indicating that 13.41 per cent CP in the ration with 28 per cent of protein supplemented as UDP was sufficient to meet the protein requirement of crossbred cows in early lactation. Also it was observed that within each level of protein consumption, increase in UDP level from 25 to 40 per cent tended to increase the milk yield even though the difference was not significant.

Various research workers had indicated that the level of protein in the ration did not affect milk production by cows in early lactation. Henderson *et al.* (1985), Leonard and Block (1988), McCormick *et al.* (1999), Bach *et al.* (2000), Sannes *et al.* (2002), Ally (2003), Davidson *et al.* (2003) and Noftsger and St- Pierre (2003) made this observation by using rations with CP levels ranging from 15.0 to 23.1 per cent in different experiments conducted in early lactation. The findings of the present study are in disagreement with the observation of Claypool *et al.* (1980) in which milk production was increased with increase in CP levels (12.7, 16 and 19 per cent CP). Similar observation was made by Klusmeyer *et al.* (1990) using 11.0 and 14.50 per cent CP rations.

As observed in the present study, the level of degradability of dietary protein did not influence the milk production as reported by several scientists. (Erdman and Vandersall, 1983; Hoffman *et al.*, 1991; Dunlap *et al.*, 2000; Sannes *et al.*, 2002). McGuffey *et al.* (1990) reported that feeding of high undegradable intake protein (UIP) led to increase in milk yield of 1.7 and 2.1 kg per day when fed 14 and 17 per cent CP rations, respectively. Kalbande and Thomas (1999) reported that average daily milk yield increased by early lactating crossbred cows from 6.32 to 10.11 kg as UDP in the concentrate mixture increased from 38 to 63 per cent.

All the dietary treatments contained one per cent urea as source of RDP. The inclusion of one per cent urea at different CP or UDP levels did not show any marked influence on the production performance of the animals indicating that urea can be added in the rations of early lactating dairy cows as a source of RDP.

5.5 MILK COMPOSITION

The milk collected from the experimental animals towards the end of each feeding period was used for the estimation of milk constituents. The values for the milk components such as fat, solids not fat, protein, total solids and milk urea nitrogen (MUN) are given in Table 7, 8 and 9 and consolidated in Table 10. There was no significant difference (P>0.05) between the four dietary groups regarding the average fat percentages (4.06, 3.95, 4.0 and 4.08 g per cent, respectively). Milk fat content increased from 3.6 (first period) to 4.6 (fourth period) in group I. The corresponding values, respectively, being 3.1 to 4.8 in were group II, 3.4 to 4.3 in group III and 3.5 to 4.4 in group IV. Claypool *et al.* (1980) reported a fat per cent of 3.6, 3.2 and 3.4 in milk of animals fed 12.7, 16.3 and 19.3 per cent CP rations, which was not significantly affected. Klusmeyer *et al.* (1990) reported that milk contained 3.42 and 3.53 per cent fat when fed 11.0 and 14.50 per cent CP rations in early lactation. Milk fat per cent and milk protein were not affected by protein concentration in the ration as reported by Edwards *et al.* (1980), Roffler and Thacker (1983) and Howard *et al.* (1987).

Hoffman *et al.* (1991) opined that additional intake of undegradable protein had no effect on milk protein or fat and on milk fatty acid composition. On the contrary, Aharoni *et al.* (1993) observed that fat percentage were higher when degradability of 17 per cent CP ration decreased from 70 to 65 per cent and the increase in fat yield were 0.196 kg per day in cows producing 35 kg milk per day. However, in the present study no change (P>0.05) in milk fat percentage could be observed in response to increase in UDP level in the ration. Similar lack of effect of UDP level on milk fat percentage (4.64g per cent) was reported by Kalbande (1995) where as Windschitl (1991) observed that substitution of salmon meal for SBM, which increased UDP from 28.8 to 35.6 per cent, reduced milk fat per cent and yield with no effect on the yield of milk protein.

In the current study, the four dietary treatments did not affect (P>0.05) the milk protein percentages and the average protein content of the four groups were 2.86, 2.55, 2.76 and 2.64 g per cent. A similar level of milk protein (2.8 per cent) was observed by Christensen *et al.* (1993b) using 16.4 per cent CP ration where as a slightly higher levels of 3.31 and 3.27 per cent protein was observed by Klusmeyer *et al.* (1990) with 11.0 and 14.5 CP per cent rations, respectively. Ally (2003) also reported milk protein content of 2.59, 2.54 and 2.52 per cent, respectively, when crossbred cows were fed 13.2, 15.4 and 20 per cent CP ration during early lactation.

In the present study, milk protein percentages were lower for cows fed 39.15 and 40 per cent UDP, respectively, in 17 and 20 per cent CP concentrate mixtures (2.55 and 2.64 g per cent, respectively) compared to those fed same CP concentrate mixtures with 28 and 26.46 per cent UDP (2.86 and 2.76 g per cent) even though the difference was not significant (P>0.05). Similarly, Rodriguez *et al.* (1997) reported a reduction in milk protein percentages from 3.72 to 3.56 as the rumen undegradable protein (RUP) level increased from 29 to 41 per cent. In contrast, Baker *et al.* (1995) reported an increase in milk protein content from 2.89 to 3.01 g per cent by increasing the UDP level in the ration. The finding of the present study was in agreement with the reports of Kalbande (1995) and Ally (2003). They observed that UDP levels in the ration had no significant effect on milk protein percentages in crossbred cows with peak production of 10 kg milk per day.

The average solids not fat (SNF) in the milk from animals fed four experimental rations were 8.88, 8.30, 8.60 and 8.76 g per cent, respectively and there was no significant difference (P>0.05) between the four groups. Similarly, Henderson *et al.* (1985) observed no significant difference in the SNF content (8.80, 8.74 and 8.78 per cent) of milk with 15, 16 and 22 per cent CP rations and also by Christensen *et al.* (1993b) with 16 and 19 per cent CP rations. But Edwards *et al.* (1980) found that solids not fat (SNF) was lower for milk from cows fed 13 per cent CP compared to 15 or 17 CP ration. The average total solids in the milk from animals fed four experimental rations were 12.80, 12.10, 12.60 and 12.80 g per cent, respectively. The average SNF and total solids percentages of the milk from the animals maintained on four dietary treatments were similar (P>0.05) irrespective of the difference in the UDP levels and this observation is in agreement with the report of Nianogo *et al.* (1991). Christensen *et al.* (1993a) also found that there was no change in SNF levels in milk by source or degradability of protein (65 and 70 per cent) in the 16.4 and 20 per cent CP ration, where as an increase in SNF level by supplementing fish meal as source of RUP in the ration as reported by Vagoni and Broderick (1997). Kalbande (1995) observed a significant increase in total solids as the UDP level in the concentrate mixture decreased from 63 to 30 per cent during early lactation.

Claypool *et al.* (1980) reported that milk composition was not affected by rations with different CP levels (13, 16 and 19 per cent) in early lactation. Similar observation of other scientists on the lack of significant effect on milk components by dietary CP levels ranging from 13.2 to 20 per cent (Barney *et al.*, 1981; Sannes *et al.*, 2002; Davidson *et al.*, 2003; Ally, 2003) or UDP levels ranging from 27 to 66 per cent (Zimmerman *et al.*, 1992; Rodriguez *et al.*, 1997; Ally, 2003; Davidson *et al.*, 2003) correlates well with the observations made in the present study.

The average milk urea nitrogen (MUN) concentrations recorded in this feeding trial were 40.67, 37.77, 44.15 and 41.92 mg /100 ml when animals fed 17 and 20 per cent CP concentrate mixtures at 28, 39.15, 26.46 and 40 per cent UDP. Oltner and Wiktorsson (1983) reported a MUN level between 38 to 76 mg per cent with dietary CP levels ranging from 12.4 and 19.2 per cent in early lactation. Bector *et al.* (1998) reported that MUN levels in lactating cows ranged between 22.8 to 92.4 mg per cent and the average being 53.36 mg per cent. The protein level in the concentrate mixtures significantly affected (P<0.05) the MUN concentrations in the present study. The MUN levels were greater with 20 per cent concentrate mixtures compared with that of 17 per cent concentrate mixtures indicating that animals given 20 per cent concentrate mixture were receiving excess protein, which was catabolised and excreted through milk. This observation was in agreement with the reports of Bach *et al.* (2000) with 15 and 18 per cent CP, Kauffman and St-Pierre (2001) with 13 and 17 per cent CP, Noftsger and St- Pierre (2003) with 17 and 18.3 per cent CP and Broderick (2003) with 15.1, 16.7 and 18.4 per cent CP rations and they observed MUN ranging from 6.09 to 19.09 mg per 100 ml in early lactation.

In the present study, different UDP levels had no significant effect on MUN concentrations (P>0.05). But, as the UDP level in the dietary treatments increased from 28 to 39.15 per cent in 17 per cent CP concentrate mixtures and from 26.46 to 40 per cent in 20 per cent CP concentrate mixtures, there was a reduction in MUN levels. In accordance this observation, Rodriguez *et al.* (1997) also observed a non significant decrease in MUN in Holstein cows when UDP content of 16.2 per cent ration increased from 29 to 41 per cent. The MUN concentration is dependent on nitrogen metabolism and is useful for rapidly identifying the sudden alterations in dietary CP content or intake. Thus its estimation helps to reduce overfeeding of protein and the excessive excretion of urinary nitrogen that accompanies CP overfeeding (Broderick, 2003).

5.6 RUMEN FERMENTATION PARAMETERS

The average values on rumen pH, rumen ammonia nitrogen ($NH_3$–N) and total volatile fatty acid (TVFA) concentrations estimated from the rumen liquor collected at the end of each feeding period are given in Table 11 and summarised in Table 12. Rumen liquor from all the animals was collected three hours after feeding. The average pH of the rumen fluid was 7.28, 7.44, 7.49 and 7.34, respectively, for the four dietary treatments. A rumen pH of 6.44 and 6.52, respectively, with 13 and 16 per cent CP ration was reported by Claypool *et al.* (1980). Klusmeyer *et al.* (1990) reported a rumen pH of 5.89 with 11 per cent CP ration and 6.14 with 14.5 per cent CP ration. The ruminal pH in all the groups of the present study was slightly above the normal range (5.5 to 6.6) as reported by McDonald *et al.* (2002). This may be due to mixing of rumen liquor with saliva at the time of collection. In the current study, ruminal pH was not affected (P>0.05) by the CP level in the ration. This observation was in agreement with reports of various research workers (Cressman *et al.*, 1980; Claypool *et al.*, 1980; Ha and Kennely, 1984; Annextad *et al.*, 1987; Sannes *et al.*, 2002).

It could be seen from Table 12 that rumen pH was not influenced (P>0.05) by the UDP levels in the ration. This is in agreement with the reports of Rodriguez *et al.* (1997), Devant *et al.* (2001), Kanjanapruthipong *et al.* (2002), Ally (2003) and Reynal and Broderick (2003). A rumen pH ranging from 6.3 to 6.9 was reported in animals fed rations containing UDP levels between 25 and 45 per cent (Annextad *et al.*, 1987; Winsryg *et al.*, 1991; Broderick *et al.*, 1993). Seymour *et al.* (1992) recorded an average rumen pH of 6.1 from the animals maintained on 14 per cent CP at two levels of degradability (69.3 and 62.3 per cent). Khorasani *et al.* (1994) opined that mean ruminal pH was not affected by the source of protein and was higher for cows fed rapidly degradable protein based concentrates (7.03 and 7.07) than for cows fed slowly degradable protein based concentrate (6.51 and 6.7).

The average rumen $NH_3$–N concentration was 23.46, 17.40, 27.85 and 23.21 mg per cent, respectively, for the animals maintained on four experimental rations. The mean ammonia concentrations on all diets remained above the 5 mg per 100ml suggested (Roffler and Satter, 1975) as the minimum requirement for the maintenance of rumen microbial growth. It was observed that feeding of 20 per cent CP concentrate mixture at 26.46 and 40 per cent UDP produced more $NH_3$–N (27.85 and 23.21 mg per cent, respectively) compared with 17 per cent CP concentrate mixture at 28 and 39.15 per cent UDP (23.46 mg and 17.40 per cent) even though the difference was not significant (P>0.05). A linear response to $NH_3$–N concentration with increase in dietary protein levels ranging between 11.7 to 22 per cent was reported by many scientists (Kwan *et al.*, 1977;

Cressman *et al.*, 1980; Ha and Kennely, 1984; Leonard and Block, 1988; Zimmerman *et al.*, 1991; Sannes *et al.*, 2002; Davidson *et al.*, 2003). Klusmeyer *et al.* (1990) observed 10 mg per100 ml or less rumen $NH_3$–N when fed 11.0 and 14.5 per cent CP rations containing soybean meal or corn gluten meal as protein source and opined that both source and amount of CP affected the $NH_3$–N levels. The finding regarding $NH_3$–N level indicates that all the dietary treatments were adequate for the optimum microbial protein synthesis in the rumen.

The decrease in $NH_3$–N concentrations in response to increase in UDP levels observed in the current study was similar to the findings of Zimmerman *et al.* (1992), Rodriguez *et al.* (1997), Devant *et al.* (2001) and Kanjanapruthypong *et al.* (2002). The $NH_3$–N decreased from 23.43 to 17.40 mg per 100 ml with low protein diets and from 27.85 to 23.21 mg per 100 ml with high protein diet in response to increase in UDP levels. This is because dietary protein that is more degradable in the rumen promotes the ammonia production by the microbes in the rumen. However, rumen $NH_3$–N was not significantly affected ($P>0.05$) by different levels of UDP in the concentrate mixtures.

The average TVFA concentrations of rumen liquor collected from animals fed four dietary treatments were110, 94.38, 107.38 and 96.44 meq/l, respectively. The levels were not significantly different ($P>0.05$) between the treatments and were within the normal range of 70 to 150 meq/l (McDonald *et al.,* 2002). The observation in the present study is in agreement with the reports of Cressman *et al.* (1980), Ha and Kennely (1984), Zimmerman *et al.* (1991), Korhonen *et al.* (2002) and Davidson *et al.* (2003) and they did not get any significant effect on TVFA production by various levels of CP in the ration.

Annextad *et al.* (1987) reported a TVFA level of 68 to 81 mmol/l when 16 per cent CP rations containing 31 and 42 per cent UDP were fed, while, Vagoni and Broderick (1997) observed a TVFA level of 150 and 170 mmol/l by feeding 17 to 18 per cent CP ration containing fish meal. The observation made in the present study agrees with the findings of O'Mara *et al.* (1998), Meng *et al.* (2000), Sannes *et al.* (2002) and Ally (2003) in which TVFA concentration of rumen liquor was not affected by the level of UDP. However, Davidson *et al.* (2003), observed that greater amount of degradable protein in the ration resulted in an increase in TVFA concentration.

5.7 HAEMATOLOGICAL AND BIOCHEMICAL PARAMETERS

The data on the haematological parameters like haemoglobin and various biochemical parameters such as plasma urea nitrogen, plasma glucose, plasma creatinine, total protein, albumin, plasma calcium and phosphorus levels of the blood samples collected at the end of each feeding period are given in Table 13, 14, 15 and 16 and summarised in Table 17. It is noted that all the values obtained ranges between the normal levels specific for the cows (Kaneko, 1997). None of the parameters in the present study were significantly affected ($P>0.05$) by the four dietary treatments.

The average haemoglobin concentrations were 8.93, 8.95, 8.13 and 8.71 g per 100ml, respectively, for the animals fed four experimental rations. The lack of significant effect of dietary protein and UDP level on haemoglobin concentration in early lactation was also reported by Ally (2003) and the haemoglobin levels were 10 g per cent in cows fed 17 per cent concentrate mixture with 26.8 per cent UDP, while, 10.58 g per cent haemoglobin was recorded in animals fed the same CP concentrate mixture with 42.9 per cent UDP. Ramakrishna (2003) also observed uniform levels of haemoglobin (9.92 to 10.59 g/100ml) in Jersey crossbred cows maintained on different feeding regimens with straw based ration.

The average plasma glucose levels (PGL) of the animals fed four experimental rations were 46.17, 46.32, 49.80 and 49.53 mg per 100 ml, respectively. The PGL levels were not significantly affected ($P>0.05$) with the different dietary combinations. It could be seen that PGL levels tend to increase (though not significant) corresponding to an increase in CP in the concentrate mixture from 17 to 20 per cent. This finding is in disagreement with that of Bach *et al.* (2000) who observed a decrease in blood glucose level (BGL), though not significant, with increase in protein levels in the ration from 15 to 18 per cent. Korhonen *et al.* (2002) also reported a decrease in BGL as the CP level increased from 13.4 to 17 per cent in the ration. Hypoglycaemic condition during early lactation can be expected due to drainage of glucose for lactose synthesis. However, none of the animals showed any signs of ketosis.

The average plasma urea nitrogen (PUN) recorded were 12.81, 15.90, 17.46 and 13.82 mg per100 ml, respectively, from the animals maintained on four experimental rations. Eventhough the level was numerically higher when cows fed 20 per cent CP concentrate mixture with 25 per cent UDP (17.46 mg/100ml) than those fed 17 per cent concentrate mixture (12.81 mg/100ml) having same level of degradability, there was no significant effect (P>0.05) on PUN concentrations by the different dietary treatments in the present study. Zimmerman *et al.* (1991) also observed that PUN was not significantly affected when cows fed 14, 18 and 22 per cent CP rations having 11 per cent fibre from fifth to twelfeth week of lactation. On the other hand, Roseler *et al.* (1993), Bach *et al.* (2000), Kauffman and St-Pierre (2001), Davidson *et al.* (2003) and Noftsger and St- Pierre (2003) reported an increase in PUN in response to increase in dietary CP level.

There was no significant effect of UDP levels on PUN concentrations in the present study. Rodriguez *et al.* (1997) also found that there was no significant difference in the PUN level when UDP of a 16 per cent ration was increased from 29 to 41 per cent. Similar observation was made by Ally (2003) when 17 per cent CP concentrate mixture with 26.8 and 42.9 per cent degradability were given to cows in early lactation where as Wiley *et al.* (1991) reported a higher level of blood urea nitrogen (BUN) when cows fed ration supplemented with UDP sources (22.64 mg/100ml) than those fed rations supplemented with RDP sources (19.91 mg/100ml) in early lactation. The plasma creatinine was 1.29, 1.37, 1.23 and 1.57 mg per 100ml, respectively, for the animals fed four experimental rations and were not affected (P>0.05) by the four dietary treatments. Wiley *et al.* (1991) also observed serum creatinine ranging from 1.39 to 2.71 mg per 100 ml and that the levels were not affected by post partum protein sources.

The average plasma calcium content of the animals fed four experimental rations was 8.84, 9.15, 9.19 and 9.64 mg per 100 ml and the plasma phosphorus content was 5.0, 4.99, 4.79 and 5.26 mg per 100 ml, respectively. This indicates that the level of CP and UDP has not influenced the plasma calcium and phosphorus levels. Jordan *et al.* (1983) observed that concentration of calcium was similar (10.5 mg/100ml) in both 12 and 23 per cent CP ration, while, plasma phosphorus was higher in cows fed 23 per cent CP ration (6.1 mg/100ml) compared to those fed 12 per cent CP ration. Ally (2003) recorded plasma calcium of 10.86 and 9.80 mg per 100ml and plasma phosphorus of 6.5 and 6.24 mg per100 ml in 17 per cent concentrate mixtures with 26.8 and 42.9 per cent UDP, respectively. These observations are in agreement with that of present study as dietary combinations had no significant effect (P>0.05) on both plasma calcium and phosphorus levels.

The plasma total protein concentrations in animals belonging to the four dietary treatments were 7.11, 6.61, 6.65 and 6.85 g per 100 ml and the plasma albumin concentrations were 3.24, 3.55, 3.46 and 3.37 g per 100 ml, respectively. In this study the dietary protein and its degradability did not significantly affect (P>0.05) both the plasma total protein and albumin. Ramakrishna (2003) also reported that plasma total protein levels were (6.22 to 6.98 g/100ml) similar in crossbred cows maintained under different nutritional managements. In contrast, Cressman *et al.* (1980) observed that total protein of plasma was increased significantly from 7.89 to 8.84 g per 100 ml when protein levels in the ration increased from 12 to 18 per cent. Kwan *et al.* (1977) reported a non significant increase in plasma albumin by increasing the dietary CP levels from 11.7 to 16.6 per cent in early lactation. The plasma albumin obtained in the present study agrees with the reports of Claypool *et al.* (1980) in which albumin ranged from

3.40 to 3.79 g per 100 ml when fed different CP rations (12.7, 16.3 and 19.3 per cent) in early lactation.

5.8 ECONOMICS OF PRODUCTION

Data on the feed intake, total milk production and cost of production in the study are presented in Table 18. The total dry matter intake of the animals of the four groups was 1978.30, 1957.15, 1982.75 and 1993.05 kg, respectively. DMI of all groups were similar. The total milk produced in 84 days by the animals given the four dietary treatments were 1562.40, 1627.90, 1508.64 and 1631.24 kg, respectively. Although the milk production was higher in animals fed high UDP diets (T2 and T4) statistical analysis of the data revealed a non significant difference (P>0.05). Cows that received 20 per cent CP concentrate mixture with 40 per cent UDP produced 1.46 kg more milk per day than those fed same CP concentrate mixture with 26.46 per cent UDP. Similarly, cows fed 17 per cent CP concentrate mixture with 39.15 per cent UDP produced 0.8 kg more milk per day than those fed concentrate mixture of same CP with 28 per cent UDP. This indicates that the efficiency of production was higher with high UDP rations compared with low UDP rations in early lactating crossbred cows.

High protein with high UDP concentrate mixture was (T4) the costliest and the low protein low UDP concentrate mixture (T1) was the cheapest among the four concentrate mixtures. The cost of concentrates mixtures per kg for T1, T2, T3 and T4 were Rs.7.01, 8.10, 7.61 and 9.50, respectively. The cost of production per kg milk produced was Rs.7.25, 8.49, 8.05 and 9.09, respectively, for the four dietary treatments. It was highest in animals maintained on T4 ration because of high cost of feed. Claypool *et al.* (1980) reported that cows fed 16 per cent CP rations had highest return over feed cost than those fed 19 per cent CP ration, while, Roffler and Thacker (1983) observed that returns above feed cost were greater for the 16.5 per cent CP ration compared with 13.5 per cent CP ration.

From the overall results obtained in the present study it could be concluded that a 17 per cent CP concentrate mixture containing one per cent urea as source of RDP with 28 per cent of protein as UDP was sufficient for meeting the protein requirement of early lactating crossbred cows producing about 10 kg milk per day. It could also be concluded that urea can be included at one per cent level as source of RDP in the concentrate mixture of early lactating cows without any deleterious effect.

# Summary

# 6. SUMMARY

A study was conducted in crossbred cows to assess the effect of urea as a source of rumen degradable protein on the milk production in early lactation. Eight crossbred cows within 20 days of lactation as uniform as possible with regard to their age, parity, weight and milk yield, were selected from ULF & FRDS as the experimental animals. They were allotted to the four dietary treatments in a switch over design. The four concentrate mixtures contained 16.93, 17.37, 19.92 and 19.92 per cent crude protein (CP) and 70.60, 69.24, 70.26 and 68.98 per cent TDN, respectively. The CP content of the four experimental rations formulated with concentrate mixture and paddy straw in the ratio of 70: 30 was 13.41, 13.71, 15.50 and 15.50 per cent, respectively. The levels of rumen undegradable protein (UDP) and rumen degradable protein (RDP) in the four concentrate mixtures were 28, 39.15, 26.46 and 40 per cent of CP as UDP and 72, 61.85, 73.54 and 60 per cent of CP as RDP, respectively, on DM basis.

The feeding trial was conducted in a switch over design. Each treatment was given for a period of three weeks and a period of seven days was given in between the treatments to nullify the carry over effects of previous treatment. The total experiment was for 15 weeks and the cows were maintained under similar managemental conditions. The cows were fed as per NRC (1989) standards. Data on the daily DM intake and milk yield were maintained through out the experiment. The body weight of animals was recorded at the beginning and end of each feeding period. Milk, blood and rumen liquor were collected from the animals at the beginning and end of each feeding period. The parameters estimated from milk samples were milk fat, protein, total solids, solids not fat (SNF) and milk urea nitrogen (MUN) and from blood samples were haemoglobin, plasma glucose, plasma urea nitrogen, plasma creatinine, plasma calcium, plasma phosphorus, plasma total protein and albumin. The rumen pH, total volatile fatty acids and (TVFA) and rumen ammonia nitrogen ($NH_3$–N) were estimated from

the rumen liquor collected. The data obtained were analysed by the method of analysis for switch over design.

There was no significant effect (P>0.05) of dietary CP or UDP level on the body weights of animals. The initial body weight of the animals in the four groups was 392.5, 369.5, 362.5 and 329 kg, respectively. The average daily dry matter intake (DMI) of animals in the four groups was 10.53, 10.54, 10.53, and 10.65 kg, respectively. The DMI of the animals as per cent of their body weight in the four groups were also similar and were 3.03, 3.01, 3.0 and 3.03 per cent, respectively.

The milk production was not significantly affected (P>0.05) either by the levels of CP (17 or 20) or degradability (28, 39.15, 26.46 and 40 per cent) in the ration. The average daily milk production of the animals was 9.30, 9.68, 8.98 and 9.71 kg, respectively, for the four dietary treatments. The inclusion of urea at different CP or UDP levels did not show any marked influence on the production performance of the animals.

The average milk composition was 4.06, 3.95, 4.0 and 4.08 g per cent fat; 2.86, 2.55, 2.76 and 2.64 g per cent protein; 8.88, 8.30, 8.60 and 8.76 g per cent solids not fat (SNF); 12.80, 12.10, 12.60 and 12.80 g per cent total solids and 40.67, 37.77, 44.15 and 41.92 mg/100 ml milk urea nitrogen (MUN), respectively, for the animals maintained on four experimental rations. There was no significant difference (P>0.05) in any of these parameters except MUN. The MUN concentration was significantly higher (P<0.05) with 20 per cent concentrate mixtures compared to 17 per cent concentrate mixtures while UDP levels had no significant effect (P>0.05) on MUN concentrations.

The average rumen fermentation parameters estimated at the end of each feeding period were 7.28, 7.44, 7.49 and 7.34 rumen pH; 23.46, 17.40, 27.85 and 23.21 mg per cent rumen $NH_3$–N and 110, 94.38, 107.38 and 96.44 meq/l TVFA, respectively, for the animals fed four experimental rations. None of these parameters were significantly affected (P>0.05) by the four dietary treatments.

All the haematological and biochemical parameters estimated were within the normal range for the species and dietary CP and UDP levels had no significant effect (P>0.05) on them. The average values of the same were 8.93, 8.95, 8.13 and 8.71 g/100ml haemoglobin; 46.17, 46.32, 49.80 and 49.53 mg/100ml plasma glucose levels; 12.81, 15.90, 17.46 and 13.82 mg/100ml PUN; 1.29, 1.37, 1.23 and 1.57 mg/100ml creatinine; 8.84, 9.15, 9.19 and 9.64 mg/100ml plasma calcium; 5.0, 4.99, 4.79 and 5.26 mg /dl plasma phosphorus; 7.11, 6.61, 6.65 and 6.85 g/100ml plasma total protein and 3.24, 3.55, 3.46 and 3.37 g/100ml plasma albumin concentrations, respectively, in the animals belonged to the four dietary treatments.

The cost of concentrates mixtures/kg for T1, T2, T3 and T4 were Rs.7.01, 8.51, 7.61 and 9.50, respectively. The cost of production per kg milk produced was Rs.7.25, 8.10, 8.05 and 9.09, respectively, for the four dietary treatments. It was highest in animals maintained on T4 ration because of high cost of feed. Though not significant, there was a marginal increase in the milk production (0.38 kg and 0.73 kg, respectively) in both CP levels at higher UDP levels. It may not be economically viable as the cost of production was higher.

All the dietary treatments contained one per cent urea as source of RDP. Urea did not impart any significant effects on the production performance of animals, as animals fed both the CP levels at lower and higher levels of UDP performed in a similar way.

From the overall results obtained in the present study, it could be concluded that a 17 per cent CP concentrate mixture with 28 per cent UDP was sufficient for meeting the protein requirement of early lactating crossbred cows producing about 10 kg milk per day. It could also be concluded that one per cent urea can be added in the concentrate mixture of early lactating cows as a source of RDP without any deleterious effect.

# *References*

## REFERENCES

Aharoni, Y., Arieli, A and Tagari, H. 1993. Lactational response of dairy cows to change of degradability of dietary protein and organic matter. *J. Dairy Sci.* 76: 3514-3522

Ally, K. 2003. Influence of level and degradability of dietary protein on early lactation in crossbred cows. Ph.D. thesis, Kerala Agricultural University, Thrissur, p. 142

Annexstad, R.J., Stern, M.D., Otterby, D.E., Linn, J.G. and Hansen, W.P. 1987. Extruded soybeans and corn gluten meal as supplemental protein sources for lactating dairy cattle. *J. Dairy Sci.* 70: 814-822

AOAC. 1990. *Official Method of Analysis.* Fifteenth edition. Association of Official Analytical Chemists, Washington D.C., p. 587

Armentano, L.E., Bertics, S.J. and Riesterer, J. 1993. Lack of response to addition of degradable protein to a low protein diet fed to mid lactation dairy cows. *J. Dairy Sci.* 76: 3755- 3762

Arunvipas, P., Dohoo, I.R., Van Leeuwen, J.A and Kerfe, G.P. 2003. The effect of non-nutritional factors on milk urea concentrations in dairy cows in Prince Edward Island, Canada. *Prev. Vet. Med.* 59: 83-93

Bach, A., Huntington, G.B., Calsamiglia, S. and Stern, M.D. 2000. Nitrogen metabolism of early lactating cows fed diets with two different levels of protein and different amino acid profiles. *J. Dairy Sci.* 83: 2585-2595

Baker, L.D., Ferguson, J.D. and Chalupa, W. 1995. Responses in urea and true protein feeding schemes for dairy cows. *J. Dairy Sci.*78: 2424- 2434

Barney, D.J., Grieve, D.G., Macleod, G.K. and Young, L.G. 1981. Response of cows to a reduction in dietary crude protein from 17% to 13% during early lactation. *J. Dairy Sci.* 64: 25-33

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. *J. Agric. Sci.* 48: 315-321

Baxter, H.D., Montgomery, M.J., Waldo, D.R. and Owen, J.R. 1983. Effect of method of feeding protein and protein insolubility on milk production by Jersey cows. *J. Dairy Sci.* 66: 2093-2099

Bector, B.S., Ram, M. and Singhal, O.P. 1998. Rapid platform test for the 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

Blauwiekel, R. and Kincaid, R.L. 1986. Effect of crude protein and solubility on performance and blood constituents of dairy cows. *J. Dairy Sci.* 69: 2091-2098

Broderick, G.A. 2003. Effects of varying dietary protein and energy levels on the production of lactating dairy cows. *J. Dairy Sci.* 86: 1370-1381

Broderick, G.A., Craig, W.M. and Ricker, D.B. 1993. Urea versus true protein as supplement for lactating dairy cows fed grain plus mixtures of Alfalfa and corn silages. *J. Dairy Sci.* 76: 2266-2274

Broderick, G.A., Mertens, D.R. and Simons R. 2002. Efficacy of carbohydrate sources for milk production by cows fed diets based on alfalfa silage. *J. Dairy Sci.* 85: 1767-1776

Butler, W.R., Calaman, J.J., and Beam, S.W. 1996. Plasma and milk urea nitrogen in relation to pregnancy rate in lactating dairy cows. *J. Anim. Sci.* 74: 858-865

Cabrita, A.R.J., Fonseca, A.J.M., Dewhurst, R.J., Sampaio, C.V.P., Miranda, M.F.S., Sousa, G.N.S., Miranda, I.M.F. and Gomes, E. 2003. Nitrogen supplementation of corn silages. 1. Effects on feed intake and milk production of dairy cows. *J. Dairy Sci.*86: 4008-4019

Cameron, M.G., Klusmeyer, T.H., Lynch, G.L., Clark, J.H. and Nelson, D.R. 1991. Effects of urea and starch on rumen fermentation, nutrient passage to the duodenum and performance of cows. *J. Dairy Sci.* 74: 1321-1336

Casper, D.P. and Schingoethe, D.J. 1986. Evaluation of urea and dried whey in diets of cow during early lactation. *J. Dairy Sci.* 69: 1346-1354

Casper, D.P., Schingoethe, D.J. and Eisenbeisz, W.A. 1990. Response of early lactation dairy cows fed diets varying in source of nonstructural carbohydrate and crude protein. *J. Dairy Sci.* 73: 1039-1050

Castillo, A.R., Kebreab, E., Beever, D.E., Barbi, J.H., Sutton, J.D., Kirby, H.C. and France, J. 2001. The effect of protein supplementation on nitrogen utilisation in lactating dairy cows fed grass silage diets. *J. Anim. Sci.* 79: 247-253

Christensen, R.A., Lynch, G.L. and Clark, J.H. 1993a. Influence of amount and degradability of protein on production of milk components by lactating Holstein cows. *J. Dairy Sci.* 76: 3490-3496

Christensen, R.A., Cameron, M.R., Klusmeyer, T.H., Eliot, J.P., Clark, J.H. and Nelson, D.R and YU.Y. 1993b. Influence of amount and degradability of dietary protein on nitrogen utilization by dairy cows. *J. Dairy Sci.* 76: 3497-3513

Clark, J.H. and Davis, C.L. 1980. Some aspects of feeding high producing cows. *J. Dairy Sci.* 63: 873-885

Clark, J.H., Spahr, S.L. and Derrig, R.G. 1973. Urea utilization by lactating cows. *J. Dairy Sci.* 56: 763-774

Claypool, D.W., Pangborn, M.C. and Adams, H.P. 1980. Effect of dietary protein on high-producing dairy cows in early lactation. *J. Dairy Sci.* 63: 833-837

Colenbrander, V.F., Weiss, W.P., Hill, D.L. and Moeller, N.J. 1983. Ammonia and urea in corn silage based complete mixed diets for dairy cows. *J. Anim. Sci.* 56: 525-528

Colovos, N.F., Holter, J.B., Davis, H.A and Urban, W.E. 1967a. Urea for lactating dairy cattle. 1. Effects of concentrate fiber and urea levels on nutritive value of the ration. *J. Dairy Sci.* 50: 518-522

Colovos, N.F., Holter, J.B., Davis, H.A. and Urban, W.E. 1967b. Urea for lactating dairy cattle. II. Effects of various levels of concentrate urea on nutritive value of the ration. *J. Dairy Sci.* 50: 523-523

Cressman, S.G., Grieve, D.G., Macleod, G.K., Wheeler, E.E. and Young, L.G. 1980. Influence of dietary protein concentration on milk production by dairy cattle in early lactation. *J. Dairy Sci.* 63: 1839-1847

Crish, E.M., Wohlt, J.E. and Evans, J.L.1986. Insoluble nitrogen for milk production in Holstein cows via increases in voluntary intake and nitrogen utilization. *J. Dairy Sci.* 69: 1576-1586

Cunningham, K.D., Cecava, M.J., Johnson, T.R. and Ludden, P.A. 1996. Influence of source and amount of dietary protein on milk yield by cows in early lactation. *J. Dairy Sci.* 79:620-630

Davidson, S., Hopkins, B.A., Diaz, D.E., Bott, S.M., Brownie, C., Fellner, V. and Whitlow, L.W. 2003. Effects of amount and degradability of dietary protein on lactation, nitrogen utilization and excretion in early lactation Holstein cows. *J. Dairy Sci.* 86:1681-1689

De Peters, E.J. and Ferguson, J.D.1992. Non protein nitrogen and protein distribution in the milk of cows. *J. Dairy Sci.* 75: 3192-3209

Devant, M., Ferret, A., Calasmiglia, S., Casals, R. and Gasa, J. 2001. Effect of nitrogen source in high- concentrate, low-protein beef cattle diets on microbial fermentation studied in vivo and in vitro. *J. Anim. Sci.* 79: 1944-1953

Dunlap, T.F., Kohn, R.A., Douglass, L.W. and Erdman, R.A. 2000. Diets deficient in rumen undegraded protein did not depress milk production. *J. Dairy Sci.* 83: 1806-1812

Edwards, J.S., Bartley, E.E. and Dayton, A.D. 1980. Effects of dietary protein concentration on lactating cows. *J. Dairy Sci.* 63: 243-248

Ensminger, M.E., Oldfield, J.E. and Heinemann, W.W. 1990. *Feed and Nutrition.* Second edition, Ensminger publishing company, California, p. 1524

Eicher, R., Bouchard, E. and Bigras-Pouline, M. 1999. Factors affecting milk urea nitrogen and protein concentrations in Quebec dairy cows. *Prev. Vet. Med.* 39: 53-56

Erb, R.E., Brown, Jr, C.M., Callahan, C.J., Moeller, N.J., Hill, D.L. and Cunningham, M.D. 1976. Dietary urea for dairy cattle. II. Effects on fuctional traits. *J. Dairy Sci.* 59: 656-667

Erdman, R.A. and Vandersall, J.H. 1983. Effect of rumen protein degradability on milk yield of dairy cows in early lactation. *J. Dairy Sci.* 66: 1873-1880

Flis, S.A and Wattiaux, M.A. 2005. Effects of parity and supply of rumen degraded and undegraded protein on production and nitrogen balance in Holsteins. *J. Dairy Sci.* 88: 2096-2106

Forster, R.J., Grieve, D.G., Buchanan-Smith, J.G. and Macleod, G.K. 1983. Effect of dietary protein degradability on cows in early lactation. *J. Dairy Sci.* 66:1653-1662

Galo, E., Emanuele, S.M., Sniffen, C.J., White, J.H. and Knapp, J.R. 2003. Effects of polymer-coated urea product on nitrogen metabolism in lactating Holstein dairy cattle. *J. Dairy Sci.* 86:2154-2162

Garg, M.R. 1998. Role of bypass protein in feeding ruminants on crop residue based diet- Review. *J. Dairy Sci.* 11:107-116

Geerts, N.E., De Brabander, D.L., Vanacker, J.M., De Boever, J.L. and Botter man, S.M. 2004. Milk urea concentrations as affected by complete diet feeding and protein balance in the rumen of dairy cattle. *Livest. Prod. Sci.* 85: 263-273

Godden, S.M., Lissemore, K.D., Kelton, D.F., Leslie, K.E., Walton, J.S. and Lumsden. J.H. 2001. Relationship between milk urea concentrations and nutritional management, production and economic variables in Ontario dairy herds. *J. Dairy Sci.* 84: 1128-1139

Greenfield, R.B., Cecava, M.J., Johnson, T.R. and Donkin, S.S. 2000. Impact of detary protein amount and rumen degradability on intake, peripartum liver tryglycrides, plasma metabolites and milk production in transition dairy cattle. *J. Dairy Sci.* 83:703-710

Grieve, D.G., Coppock, C.E., Merril, W.G. and Tyrrel, H.F. 1973. Sulphur supplementation of urea-containing silages and concentrates. I. Feed intake and lactation performance. *J. Dairy Sci.* 56: 218-228

Ha, J.K. and Kennelly, J.J. 1984. Effect of protein on nutrient digestion and milk production by Holstein cows. *J. Dairy Sci.* 67: 2302-2307

Helmer, L.G. and Bartley, E.E. 1971. Progress in the utilization of urea as a protein replacer for ruminants. A review. 25-51

Henderson, S.J., Amos, H.E. and Evans, J.J. 1985. Influence of dietary proteinconcentration and degradability on milk production, composition aruminal protein metabolism. *J. Dairy Sci.* 68: 2227-2237

Hoffman, P.C., Grummer, R.R., Shaver, R.D., Broderick, G.A. and Drendel, T.R. 1991. Feeding supplemental fat and undegraded intake protein to earl lactation dairy cows. *J. Dairy Sci.* 74: 3468-3474

Howard, H.J., Aalseth, E.P., Adams, J.D., Bush, L.J., McNew, R.W and Dawson, L.J. 1987. Influence of dietary protein on reproductive performance of dairy cows. *J. Dairy Sci.* 70: 1563-1571

Huber, J.T., Sandy, R.A., Polan, C.E., Bryant, H.T. and Blaser, R.E. 1967. Varying levels of urea for dairy cows fed corn silage as the only forage. *J. Dairy Sci.* 50: 1241-1247

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

IS: 2052. 1992. *Indian Standard Specification for Compounded Feeds for Cattle.* Third edition. Bureau of Indian Standards. New Delhi, p. 19

Jaquette, R.D., Rakes, A.H. and Croom, Jr, W.J. 1987. Effect of amount and source of dietary nitrogen on milk fat depression in early lactation dairy cows. *J. Dairy Sci.* 70: 1202-1210

Jones, G.M., Stephens, C. and Kensett, B. 1975. Utilization of starea, urea or soybean meal in complete rations for lactating dairy cows. *J. Dairy Sci.* 58: 689-695

Jonker, J.S., Kohn, R.A. and Erdman, R.A. 1998. Using milk urea nitrogen to predict nitrogen excretion and utilisation efficiency in lactating dairy cows. *J. Dairy Sci.* 81: 2681-2692

Jordan, E.R., Chapman, T.E., Holtan, D.W. and Swanson, L.V. 1983. Relationship of dietary crude protein to composition of uterine secretions and blood in high producing cows. *J. Dairy Sci.* 66: 1854-1862

Kalbande, V.H. Effect of bypass protein on yield and composition of milk in crossbred cows. 1995. Ph.D. thesis, Kerala Agricultural University, Thrissur, p.189

Kalbande, V.H. and Thomas, C.T. 1999. Effect of bypass protein on yield and composition of milk in crossbred cows. *Indian J. Anim. Sci.* 69:614-616

Kaneko, J.J., Harvey, J.W. and Bruss, M.L. 1997. *Clinical Biochemistry of Domestic animals*. Fifth edition. Academic press, California, p.905

Kanjanapruthipong, J and Buatong, N. 2002. Effects of rumen undegradable protein and minerals proteinate on early lactation performance and ovarian functions of dairy cows in the tropics. *Asian-Aust. J. Anim. Sci.* 15: 806-811

Kanjanapruthipong, J., Vajrabukka, C. and Sindhuvanich, S. 2002. Effects offormalin treated soybean as a source of rumen undegradable proteumen functions of non-lactating dairy cows on concentrate based die*Asian Aust. J. Anim. Sci.* 15: 1439-1444

Kauffman, A.J. and St- Pierre, N.R. 2001. The relationship of milk urea nitrogen to urine nitrogen excretion in Holstein and Jersey cows. *J. Dairy Sci.* 84: 2284-2294

Khorasani, G.R., De Boer, G., Robinson, B. and Kennelly, J.J. 1994. Influence of dietary protein and starch on production and metabolic responses of dairy cows. *J. Dairy Sci.*77: 813-824

Klusmeyer, T.H., McCarthy, R.D., Clark, J.H. and Nelson, D.R. 1990. Effects of source and amount of protein on ruminal fermentation and passage of nutrients to small intestine of lactating cows. *J. Dairy Sci.* 73: 3526-3537

Korhonen, M., Vanhatalo, A. and Huhtanen, P. 2002. Effect of protein source on amino acid supply, milk production and metabolism of plasma nutrients in dairy cows fed grass silage. *J. Dairy Sci.* 85: 3336-3351

Kwan, K., Coppock, C.E., Lake, G.B., Fettman, M.J., Chase, L.E. and McDowell, R.E. 1977. Use of urea by early postpartum Holstein cows. *J. Dairy Sci.* 60: 1706-1724

Leonard, M. and Block, E. 1988. Effect of ration protein content and solubility on milk production of primiparous Holstein heifers. *J. Dairy Sci.* 71: 2709-2722

Lines, L.W. and Weiss, W.P. 1996. Use of nitrogen from ammoniated alfalfa hay, urea, soybean meal and animal protein meal by lactating cows. *J. Dairy Sci.* 79: 1992-1999

Loosli, J.K and Warner, R.G. 1958. Distiller's grains, brewer's grains and urea as protein supplements for dairy rations. *J. Dairy Sci.* 41: 1446-1450

Martz, F.A., Williams, L.R., Campbell, J.R., Sikes, J.D and Hilderbrand, E.S. 1971. Frequent feeding of a corn silage-urea-concentrate blended ration to lactating dairy cows. *J. Dairy Sci.* 54: 493-496

Macleod, G.K., Grieve, D.G., McMillan, I. and Smith, G.C. 1984. Effect of varying protein and energy densities in complete rations fed to cows in first lactation. *J. Dairy Sci.* 67: 1421-1429

McCormick,M.E., Frech, D.D., Brown, T.F., Cuomo, G.J., Chapa, A.M., Fernandez, J.M., Beatty, J.F. and Blouin, D.C. 1999. Crude protein and rumen undegradable protein effects on reproduction and lactation performance of Holstein cows. *J. Dairy Sci.* 82: 2697-2708

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. 2002. *Animal Nutrition.* Sixth edition. Pearson Education Publishers, India, p. 668

McGuffey, R.K., Green, H.B. and Basson, R.P. 1990. Lactation response of dairy cows receiving bovine somatotropin and fed rations varying in crude protein and undegradable intake protein. *J. Dairy Sci.* 73: 2437-2443

Meng, Q.X., Xia, Z.G. and Kerley, M.S. 2000. The requirement of ruminal degradable protein for non-structural carbohydrate-fermenting microbes and its reaction with dilution rate in continuous culture. *Asian-Aust. J. Anim. Sci.* 13: 1399-1406

Melendez, P., Donovan, A. and Hernandez, J. 2000. Milk urea nitrogen and infertility in Florida Holstein cows. *J. Dairy Sci.* 83: 459-463

Nianogo, A.J., Amos, H.E., Froetschel, M.A. and Keery, C.M. 1991. Dietary fat, protein degradability, and calving season: effects on nutrient use and performance of early lactation cows. *J. Dairy Sci.* 74: 2243-2255

Noftsger, S. and St-Pierre, N.R. 2003. Supplementation of methionine and selection of highly digestible rumen undegradable protein to improve nitrogen efficiency for milk production. *J. Dairy Sci.* 86: 958-969

NRC. 1971. *Nutrient Requirements of Dairy cattle.* Fourth edition. National Academy of Sci., Washington, D.C. p.118

NRC. 1989. *Nutrient Requirements of Dairy cattle.* Sixth edition. National Academy of Sci., Washington, D.C. p.159

Nousiainen, J., Shingfield, K.J. and Huhtanen, P. 2004. Evaluation of milk urea nitrogen as a diagnostic of protein feeding. *J. Dairy Sci.* 87: 386-398

O'Mara, F.P., Murphy, J.J. and Rath, M. 1998. Effect of amount of dietary supplement and source of protein on milk production, ruminal fermentation and nutrient flows in dairy cows. *J. Dairy Sci.* 81: 2430-2439

Oltner, R., Emanuelson, M. and Wiktorsson, H. 1985. Urea concentrations in milk in relation to milk yield, live weight, lactation number and amount and composition of feed given to dairy cows. *Livest. Prod. Sci.*12: 47-57

Oltner, R. and Wiktorsson, H. 1983. Urea concentrations in milk and blood as influenced by feeding varying amounts of protein and energy to dairy cows. *Livest. Prod. Sci.* 10: 457-467

Plummer, J.R., Miles, J.T and Montgomery, M.J. 1971. Effect of urea in the concentrate mixture on intake and production of cows fed corn silages as the only forage. *J. Dairy Sci.* 54: 1861-1865

Ramakrishna, K.V. 2003. Studies on blood chemical constituents of crossbred jersey cows maintained under varied nutritional managements. *Indian Vet. J.* 80: 698-699

Razdan, M.N., Sharma, D.D., Bhargava, P.K. and Chawla, M.S. 1971. Utilization of urea and water metabolism by zebu cattle and buffaloes under tropical conditions. *J. Dairy Sci.* 54: 1200-1206

Reynal, S.M. and Briderick, G.A. 2003. Effects of feeding dairy cows protein supplements of varying ruminal degradability. *J. Dairy Sci.* 86: 835-843

Rodriguez, L.A., Stallings, C.C., Herbein, J.H. and McGilliard, M.L. 1997. Diurnal variation in milk and plasma urea nitrogen in Holstein and Jersey cows in response to degradable dietary protein and added fat. *J. Dairy Sci.* 80: 3368-3376

Roffler, R.E., Satter, L.D. 1975. Relationship between ruminal ammonia and non protein nitrogen utilization by ruminants. I. Development of a model for predicting non protein nitrogen utilization by cattle. *J. Dairy Sci.* 58: 1880-1898

Roffler, R.E. and Thacker, D.L. 1983. Early lactational response to supplemental protein by dairy cows fed grass-legume forage. *J. Dairy Sci.* 66: 2100-2108

Roseler, D.K., Ferguson, J .D., Sniffen, C.J. and Herrema, J. 1993. Dietary protein degradability effects on plasma and milk urea nitrogen and milk non protein nitrogen in Holstein cows. *J. Dairy Sci.* 76: 525-534

Sannes, R.A., Messman, M.A. and Vagoni, D.B. 2002. Form of rumen-degradable carbohydrate and nitrogen on microbial protein synthesis and protein efficiency of dairy cows. *J. Dairy Sci.* 85: 900-908

Santos, K.A., Stern, M.D. and Satter, L.D. 1984. Protein degradation in the rumen and amino acid absorption in the small intestine of lactating dairy cattle f fed various protein sources. *J. Anim. Sci.* 58:245-255

Schingoethe, D.J., Voelker, H. H., Beardsley, G.L. and Parsons, J.G. 1976. Rumen volatile fatty acids and milk composition from cows fed hay, haylage or urea treated corn silage. *J. Dairy Sci.* 59: 894-901

Seymour, W.M., Polan, C.E and Herbein, J.H. 1992. In vivo degradation of protein in diets formulated for two degradabilities. *J. Dairy Sci.* 75: 2447-2453

Snedecor, G.W. and Cocharan, W.G. 1985. *Statistical Methods.* Eighth edition. The Iowa State University press, America. p. 313

Sohane, R.K., Kumar, A. and Chaturvedi, V.B. 1997. Effect of Energy-protein interrelationship on high yielding dairy cow- A review. *Indian J. Anim. Res.* 31: 75-84

Son, J., Grant, R.J. and Larson, L.L. 1996. Effects of tallow and escape protein on lactational and reproductive performance of dairy cows. *J. Dairy Sci.* 79: 822-830

Srinivas, B. and Gupta, B.N. 1997. Urea-molasses-mineral block licks supplementation for milk production in crossbred cows. *Asian-Aust. J. Anim. Sci.* 10: 47-53

Tomlinson, A.P., Van Horn, H.H., Wilcox, C.J. and Harris, B. Jr. 1994. Effects of undegradable protein and supplemental fat on milk yield and composition and physiological responses of cows. *J. Dairy Sci.* 77: 145-156

Triplett, B.L., Neuendorf, D.A. and Randel, R.D. 1995. Influence of undegraded intake protein supplementation on milk production, weight gain and reproductive performance in post partum Brahman cows. *J. Anim. Sci.* 73: 3223-3229

Vagoni, D.B. and Broderick, G.A. 1997. Effect of supplementation of energy or ruminally undegraded protein to lactating cows fed alfalfa hay or silage. *J. Dairy Sci.* 80: 1703-1712

Van Horn, H.H., Foreman, C.F and Rodriguez, J.E. 1967. Effects of high-urea supplementation on feed intake and milk production of dairy cows. *J. Dairy Sci.* 50: 709-714

172382



Van Soest, P.J. 1963. Use of detergents in the analysis of fibrous feeds. II A rapid method for the determination of fibre and lignin. *J. Assoc. Off. analyt. Chem.* 46: 829

Van Soest, P.J. and Whine, R.H. 1967. Use of detergents in the analysis of fibrous feeds. IV. The determination of plant cell wall constituents. *J. Assoc. Off. analyt. Chem.* 50: 50

Wiley, J.S., Peterson, M.K., Ansotegui, R.P. and Bellows, R.A. 1991. Production from first-calf beef heifers fed a maintenance or low level of prepartum nutrition and ruminally undegradable or degradable protein postpartum. *J. Anim. Sci.* 69: 4279-4293

Yoon, J.T., Lee, J.H., Kim, C.K., Chung, Y.C. and Kim, C.H. 2004. Effects of m milk production, season, parity, and lactation period on variations of milk urea concentrations and milk components of Holstein dairy cows. *Asian-Aust. J. Anim. Sci.* 17: 479-484

Windschitl. P.M. 1991. Lactational performance of high producing dairy cows fed diets containing salmon meal and urea. *J. Dairy Sci.* 74: 3475-3485

Winsryg, M.D., Arambel, M.J. and Walters, J.L. 1991. The effect of protein degradability on milk composition and production of early lactation, somatotropin - injected cows. *J. Dairy Sci.* 74: 1648-1653

Zimmerman, C.A., Rakes, A.H., Daniel, T.E. and Hopkins, B.A. 1992. Effect of total and rumen undegradable protein on the performance of cows fed low fibre diets. *J. Dairy Sci.* 75:1954-1964

Zimmerman, C.A., Rakes, A.H., Jaquette, R.D., Hopkins, B.A. and Croom, W.J. Jr. 1991. Effects of protein level and forage source on milk production and composition in early lactation dairy cows. *J. Dairy Sci.* 74: 980-990

# EFFECT OF UREA AS A SOURCE OF RUMEN DEGRADABLE PROTEIN ON MILK PRODUCTION OF CROSSBRED COWS IN EARLY LACTATION

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Abstract of the thesis submitted in partial fulfilment of the requirement for the degree of

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# ABSTRACT

A study was conducted with crossbred cows to assess the effect of urea as a source of rumen degradable protein on the milk production in early lactation. Eight crossbred cows within 20 days of lactation were selected as uniformly as possible with regard to their age, parity, weight and milk yield. They were allotted to the four dietary treatments in a switch over design. The four concentrate mixtures contained 16.93, 17.37, 19.92 and 19.92 per cent crude protein (CP) and 70.60, 69.24, 70.26 and 68.98 per cent TDN, respectively. The levels of rumen undegradable protein (UDP) and rumen degradable protein (RDP) in the four concentrate mixtures were 28, 39.15, 26.46 and 40 per cent of CP as UDP and 72, 61.85, 73.54 and 60 per cent of CP as RDP, respectively, on DM basis.

There was no significant effect ($P>0.05$) of dietary CP or UDP levels on the body weight, dry matter intake and milk production of animals. The inclusion of urea at different CP or UDP levels did not show any marked influence on the production performance of the animals. There was no significant difference in any of milk composition parameters except MUN which was significantly higher ($P<0.05$) with 20 per cent concentrate mixtures compared to17 per cent concentrate mixtures at both levels of degradability.

The haematological and biochemical parameters such as haemoglobin, plasma glucose, plasma urea nitrogen, plasma creatinine, plasma calcium, plasma phosphorus, plasma total protein and albumin estimated at the end of each feeding period were not significantly affected ($P>0.05$) by the four dietary treatments. There was no significant effect ($P>0.05$) of four dietary combinations on rumen fermentation parameters such as rumen pH, total volatile fatty acids and (TVFA) and rumen ammonia nitrogen ($NH_3$–N) concentration. The cost of production per kg milk produced was Rs.7.25, 8.10, 8.05 and 9.09, respectively, for the four dietary treatments.

From the overall results obtained in the present study, it could be concluded that a 17 per cent CP concentrate mixture with 28 per cent UDP was sufficient for meeting the protein requirement of early lactating crossbred cows producing about 10 kg milk per day. The study also revealed that one per cent urea can be added in the concentrate mixture of early lactating cows as a source of RDP without any deleterious effect.